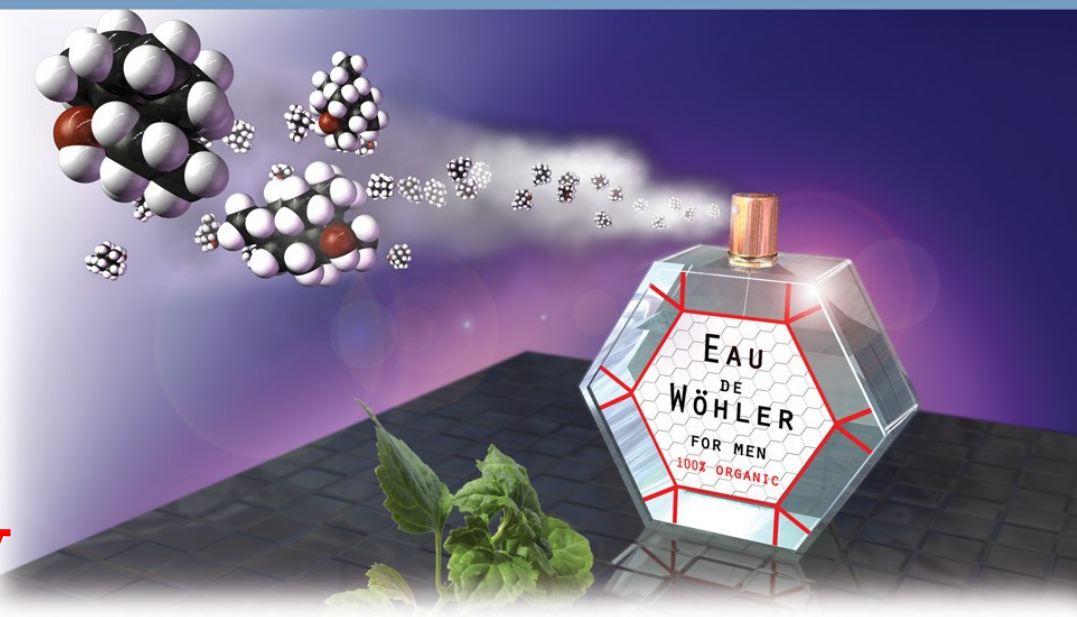


John E. McMurray and Robert C.
Fay

General Chemistry: Atoms First

**Chapter
22
Organic
Chemistry**



Prentice Hall

Uses of Hydrocarbons

Number of C	State	Major Uses
1-4	gas	heating and cooking fuel
5-7	liquids, (low	solvents, gasoline
6-18	liquids	gasoline
12-24	liquids	jet fuel; camp stove
18-50	liquids, (high boiling)	diesel fuel, lubricants, heating oil
50+	solids	petroleum jelly, paraffin wax

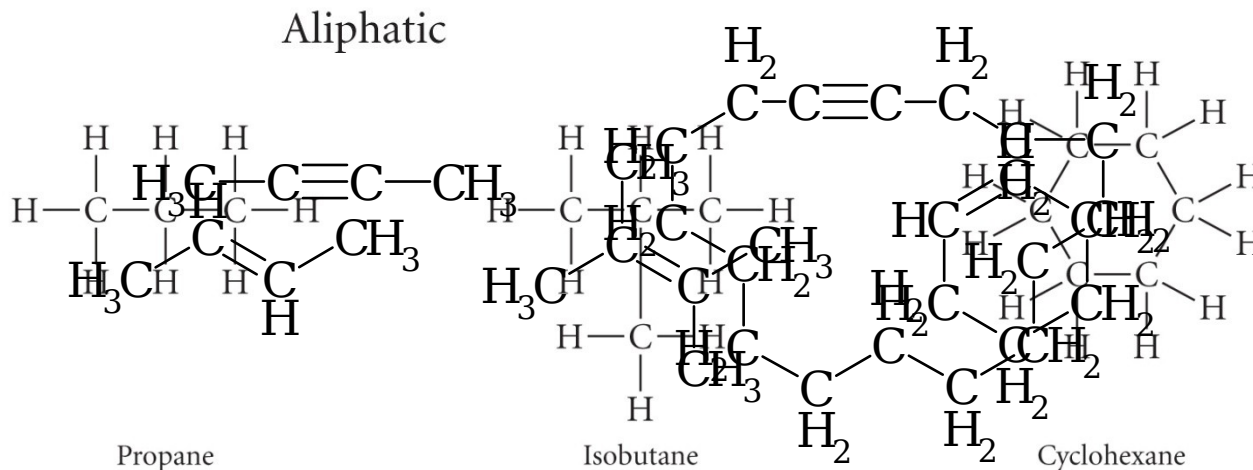
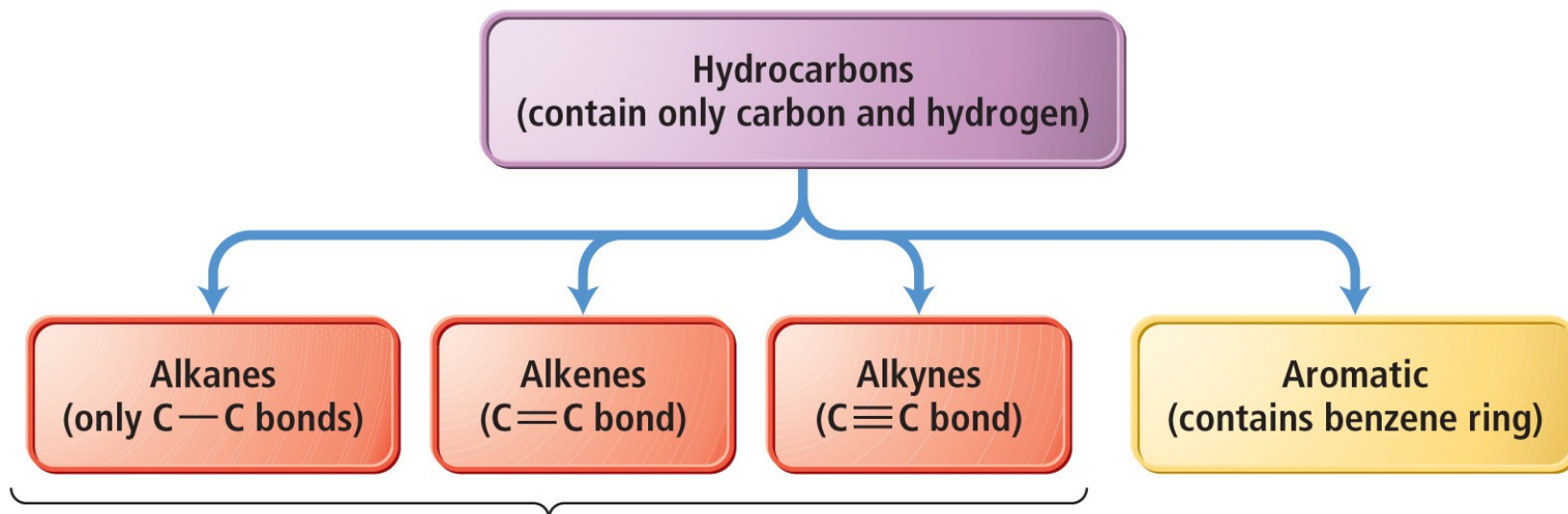


Structure Determines Properties

- Organic compounds all contain carbon
 - ✓ CO, CO₂ , carbonates and carbides are inorganic
 - ✓ other common elements are H, O, N, (P, S)
- Carbon has versatile bonding patterns
 - ✓ chains, rings, single, double and triple bonds
 - ✓ chain length nearly limitless
- Carbon compounds generally covalent
- C - C bonds unreactive (very stable)

Bond Energies and Reactivities

C-C	347 kJ	H ₃ C-CH ₃	NONREACTIVE IN AIR
S-S	214 kJ	HS-SH	EXTREMELY REACTIVE
Si-Si	213 kJ	H ₃ Si-SiH ₃	SPONTANEOUS BURNS IN AIR
N-N	159 kJ	H ₂ N-NH ₂	EXTREMELY REACTIVE
O-O	138 kJ	HO-OH	REACTIVE



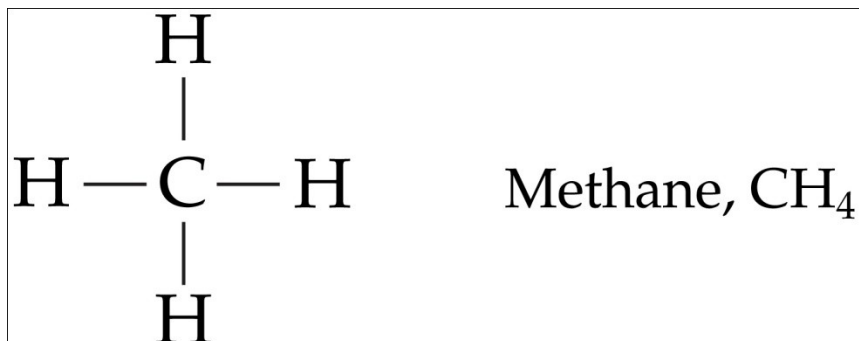
alkanes

- Methane - 1 Carbon
- Ethane - 2 Carbon Chain
- Propane - 3 Carbon Chain
- Butane - 4 Carbon Chain
- Pentane - 5 Carbon Chain
- Hexane - 6 Carbon Chain
- Heptane - 7 Carbon Chain
- Octane - 8 Carbon Chain
- Nonane - 9 Carbon Chain
- Decane - 10 Carbon Chain

The Nature of Organic Molecules

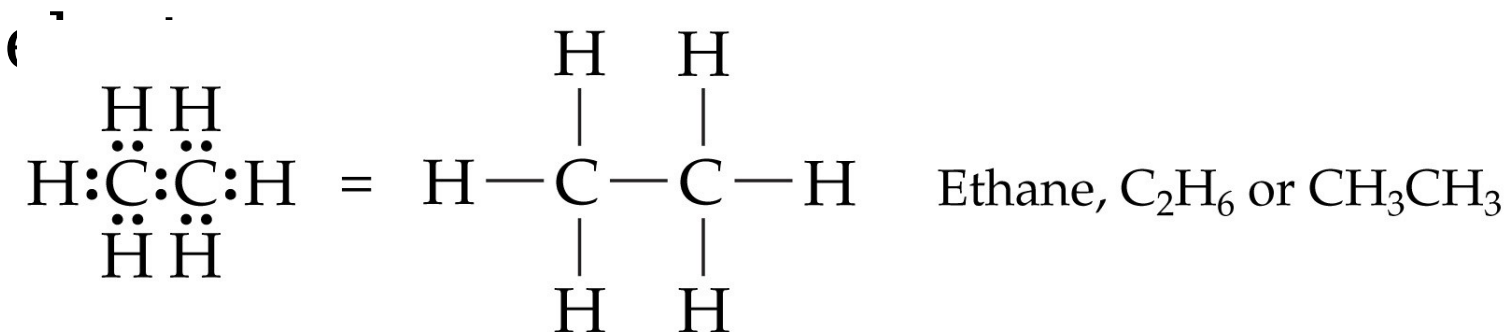
Organic Chemistry: The study of carbon compounds.

- Carbon is tetravalent. It has four outer-shell electrons ($1s^2 2s^2 2p^2$) and forms four bonds.



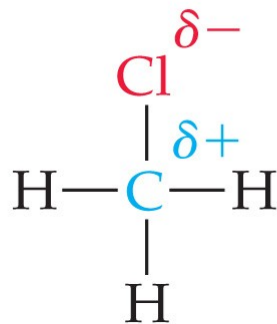
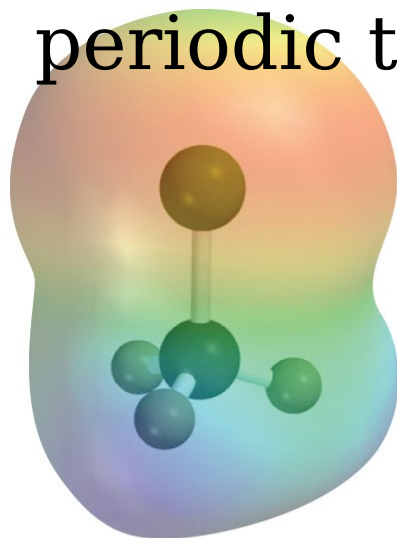
The Nature of Organic Molecules

- Organic molecules have *covalent bonds*. In ethane, for instance, all bonds result from the sharing of two

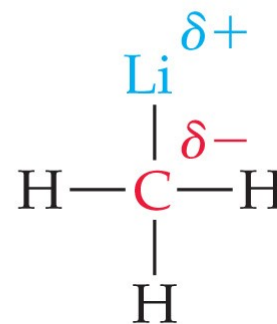
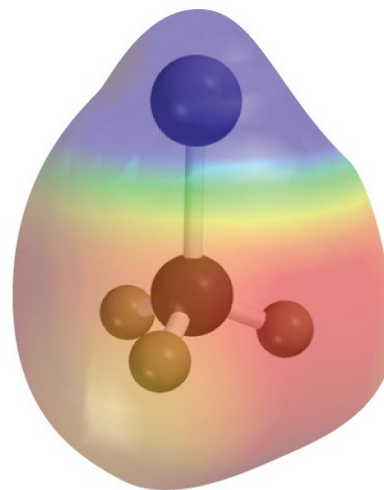


The Nature of Organic Molecules

- Organic molecules have *polar covalent bonds* when carbon bonds to an element on the right or left side of the periodic table.



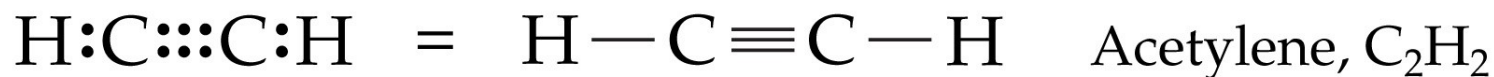
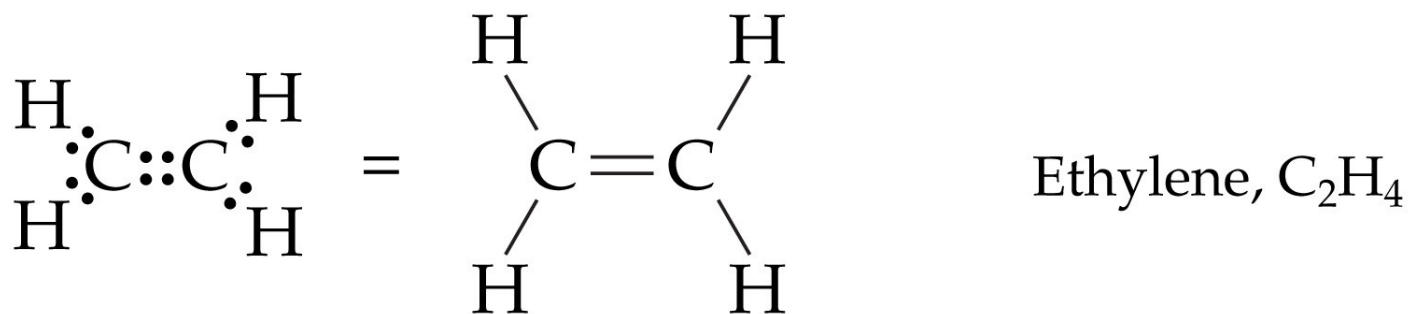
Chloromethane, CH_3Cl
(electron-poor carbon)



Methyllithium, CH_3Li
(electron-rich carbon)

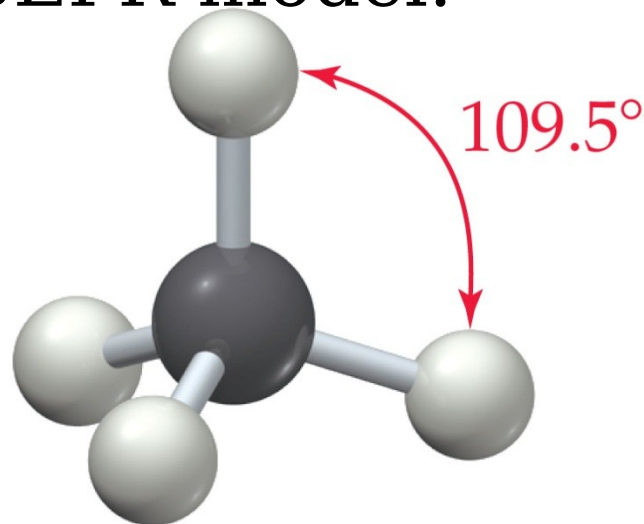
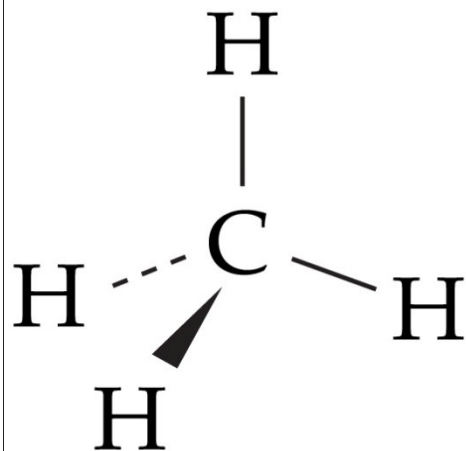
The Nature of Organic Molecules

- Carbon can form *multiple covalent bonds* by sharing more than two electrons with a neighboring atom.



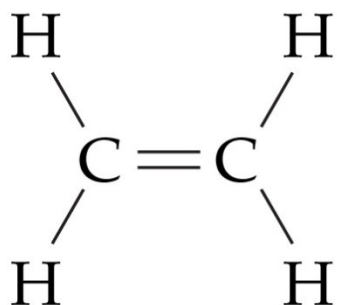
The Nature of Organic Molecules

- Organic molecules have specific three-dimensional shapes, which can be predicted by the VSEPR model.

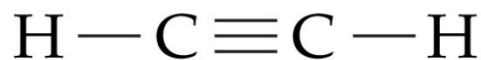
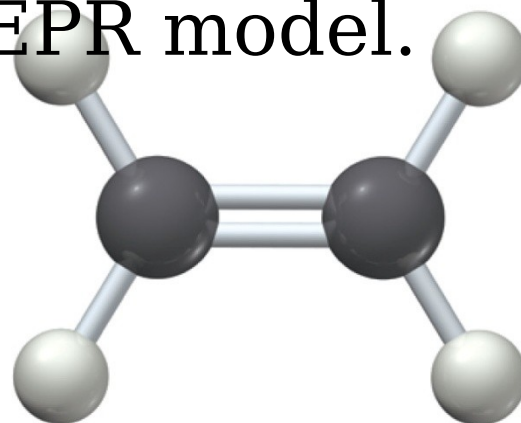


The Nature of Organic Molecules

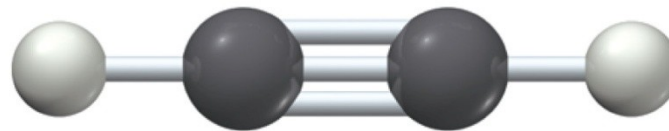
- Organic molecules have specific three-dimensional shapes, which can be predicted by the VSEPR model.



Ethylene (120° angles)

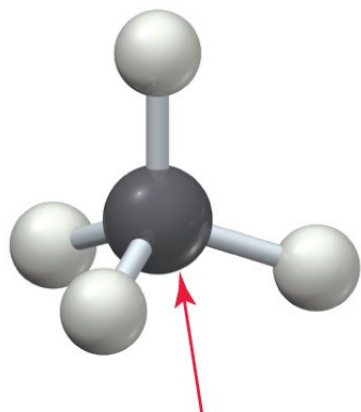


Acetylene (180° angles)

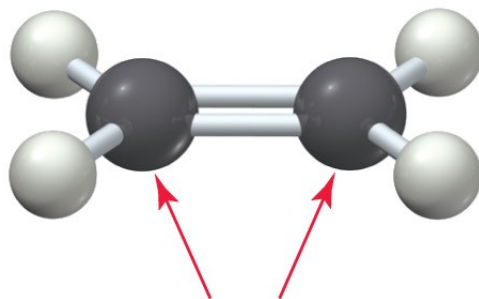


The Nature of Organic Molecules

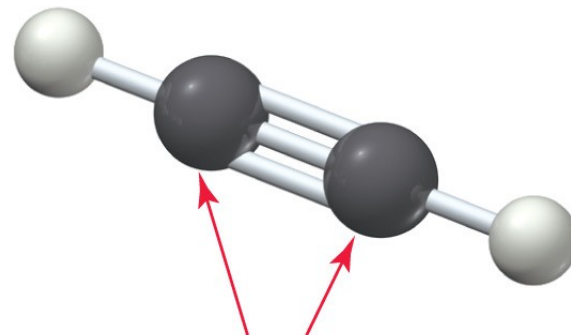
- Carbon uses *hybrid atomic orbitals* for



sp^3 hybridized



sp^2 hybridized



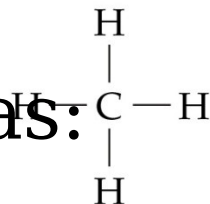
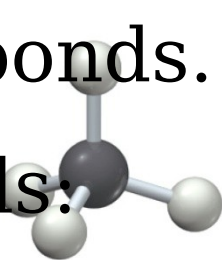
sp hybridized

Alkanes and Their Isomers

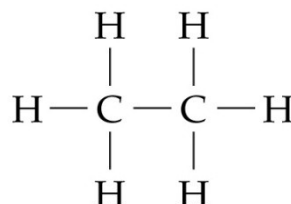
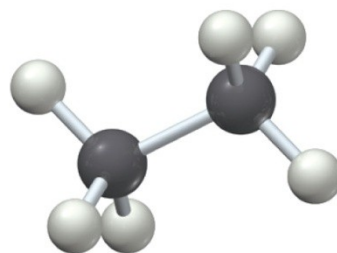
Hydrocarbons: Molecules that contain only carbon and hydrogen.

Alkanes: Hydrocarbons that contain only single bonds.

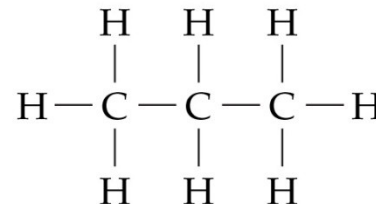
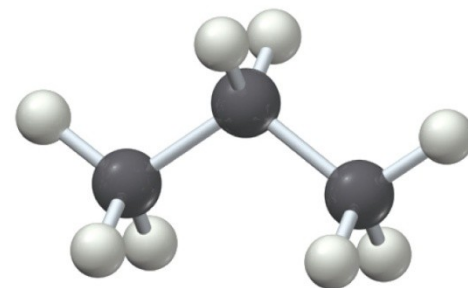
Space-filling models:



Methane, CH_4



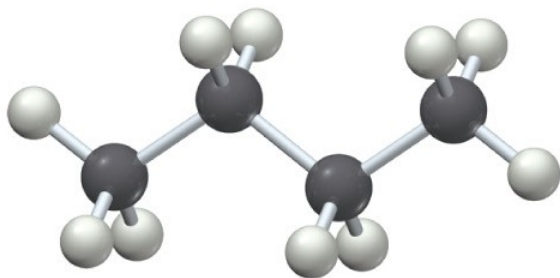
Ethane, C_2H_6



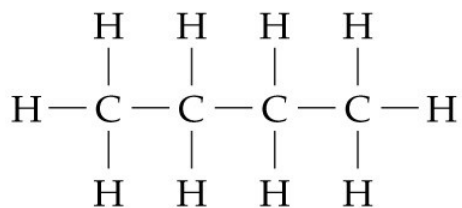
Propane, C_3H_8

Structural formulas:

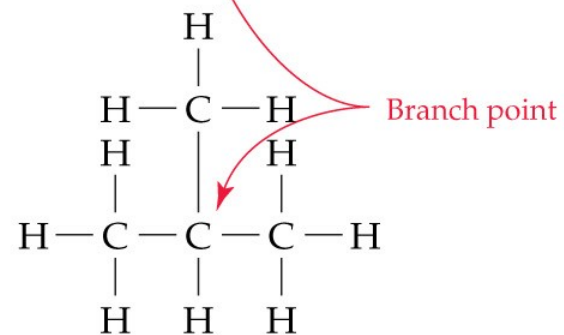
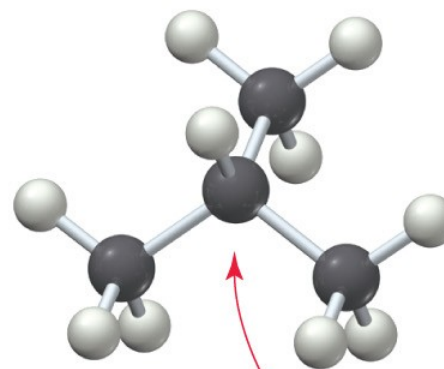
Molecular formulas:



C_4H_{10}

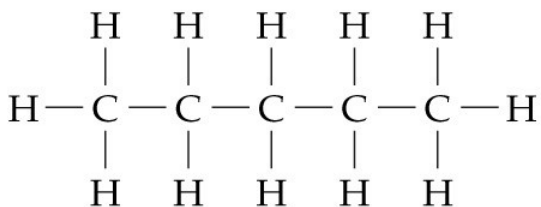


Butane (straight chain)

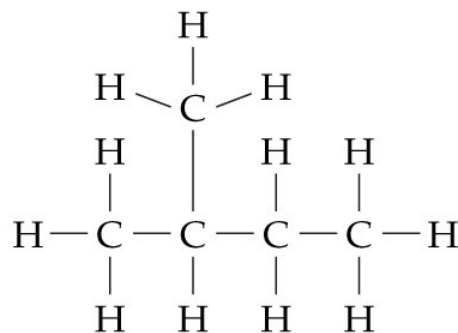


2-Methylpropane (branched chain)

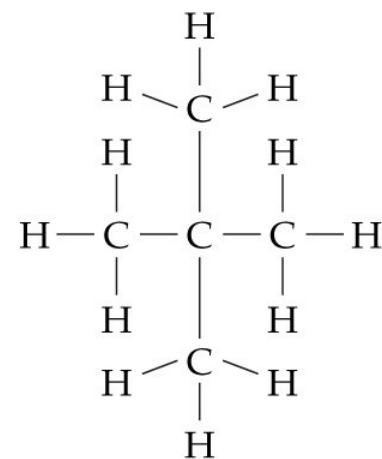
C_5H_{12}



Pentane
(straight chain)



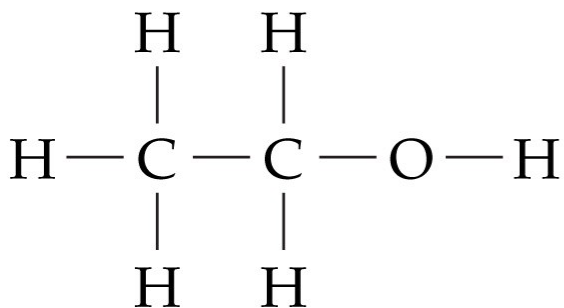
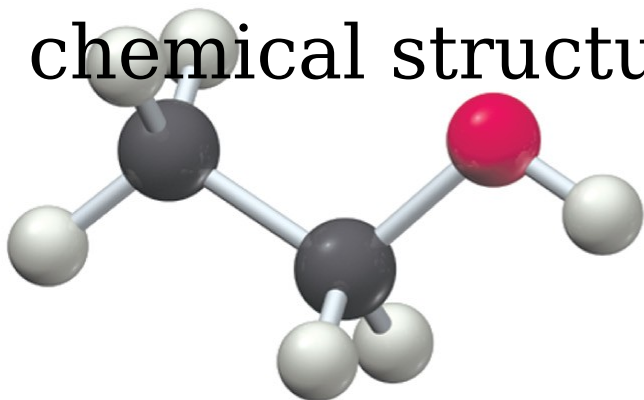
2-Methylbutane
(branched chain)



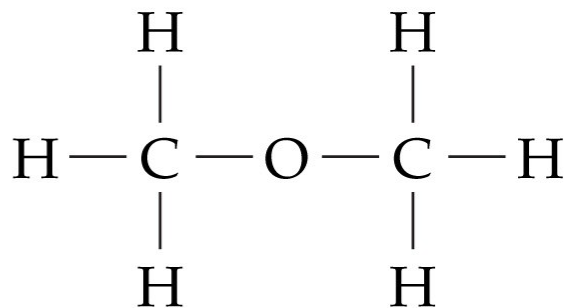
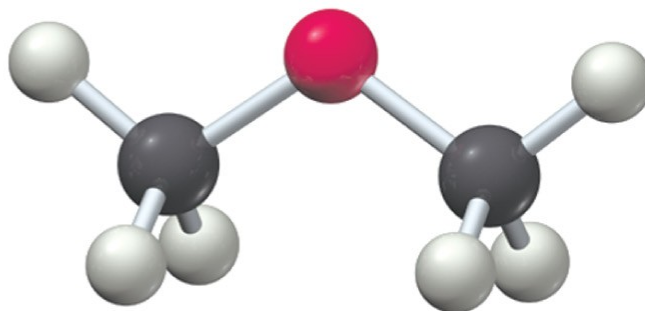
2,2-Dimethylpropane
(branched chain)

Alkanes and Their Isomers

Isomers: Compounds with the same molecular formula but different chemical structures.



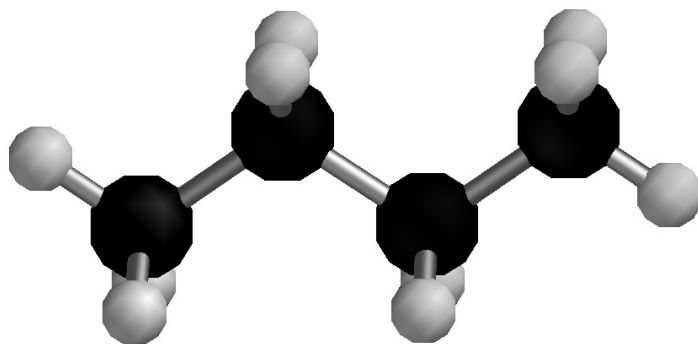
Ethyl alcohol, $\text{C}_2\text{H}_6\text{O}$



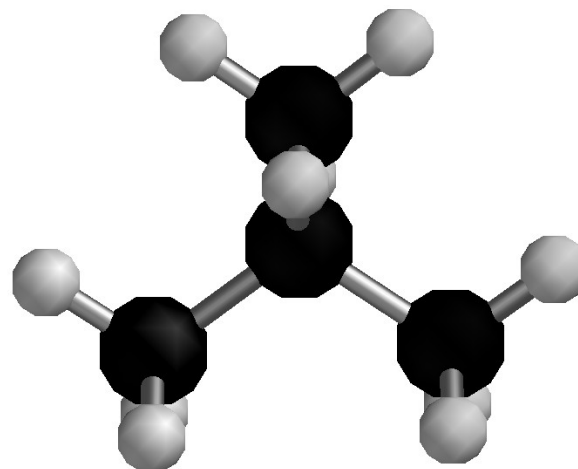
Dimethyl ether, $\text{C}_2\text{H}_6\text{O}$

Isomerism

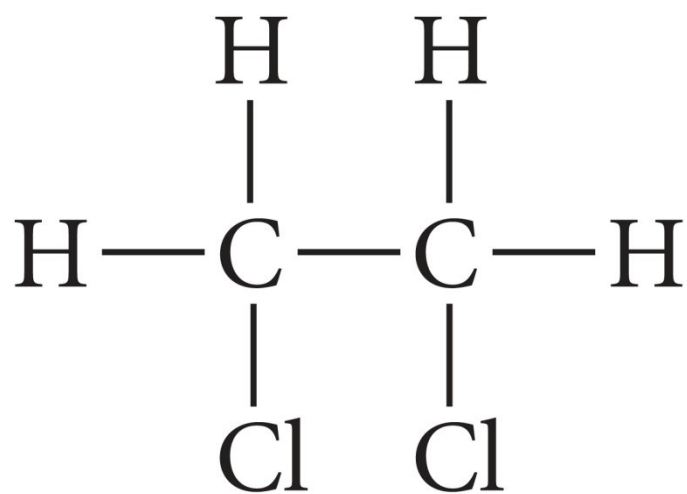
- **Isomers** = different molecules with the same molecular formula
- **Structural Isomers** = different pattern of atom attachment
 - ✓ Constitutional Isomers
- **Stereoisomers** = same atom attachments, different spatial orientation



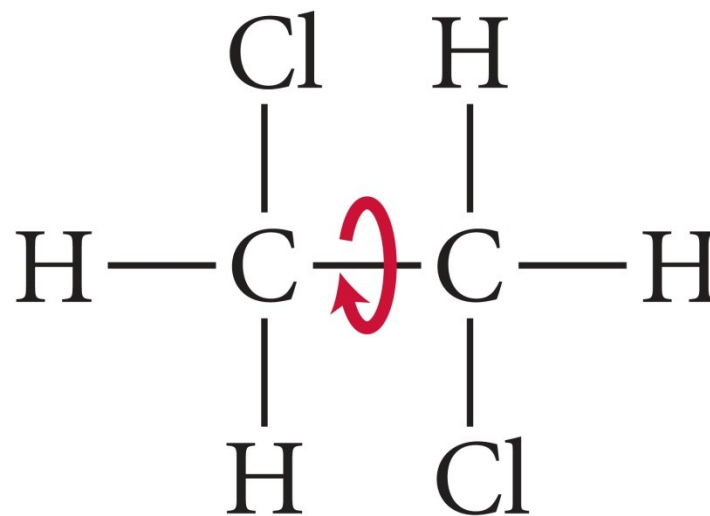
Butane



Free Rotation Around C—C



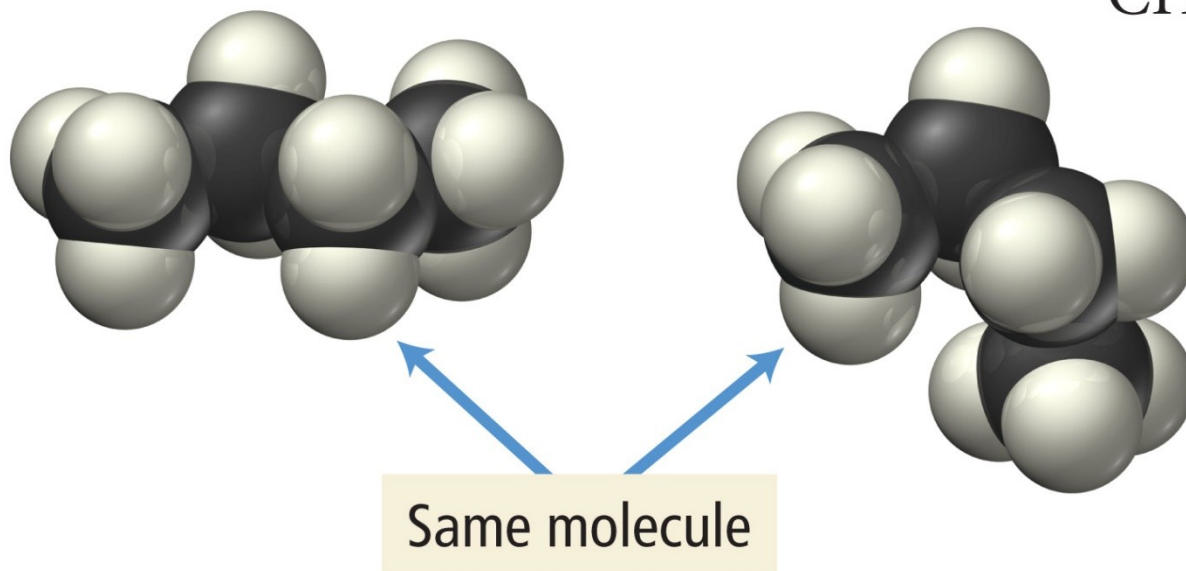
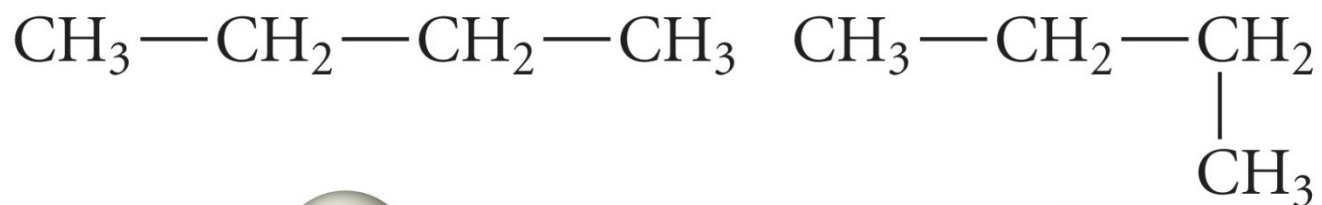
1, 2-Dichloroethane



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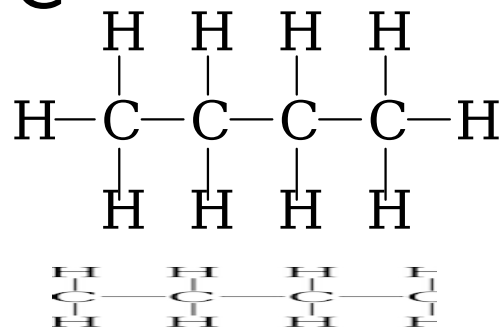
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Rotation about a bond is not isomerism

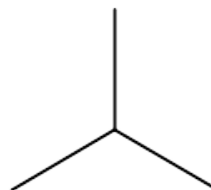
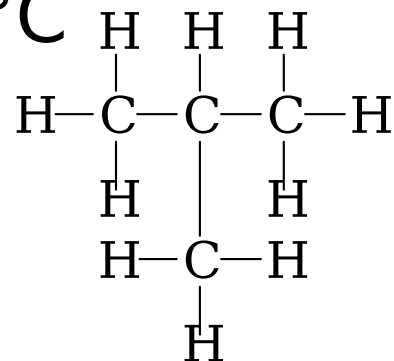


Structural Isomers of C_4H_{10}

Butane, BP = $0^{\circ}C$



Isobutane, BP = $-12^{\circ}C$



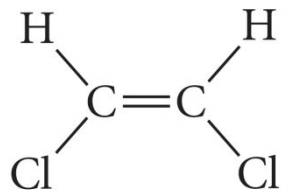
Possible Structural Isomers

Carbon Content	Molecular Formula	Possible Isomers
4	C₄H₁₀	2
5	C₅H₁₂	3
6	C₆H₁₄	5
7	C₇H₁₆	9
8	C₈H₁₈	18
9	C₉H₂₀	35
10	C₁₀H₂₂	75

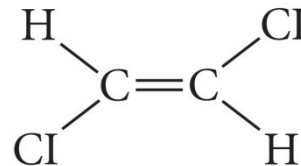
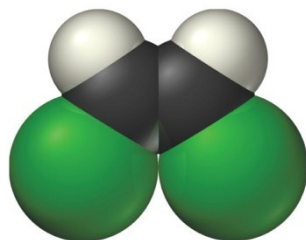
Geometric Isomerism

- because the rotation around a double bond is highly restricted, you will have different molecules if groups have different spatial orientation about the double bond
- this is often called **cis-trans isomerism**
- when groups on the doubly bonded carbons are cis, they are on the same side
- when groups on the doubly bonded carbons are trans, they are on opposite sides

Cis-Trans Isomerism



cis-1,2-Dichloroethene



trans-1,2-Dichloroethene

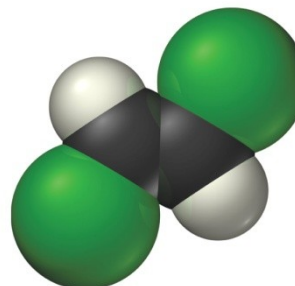


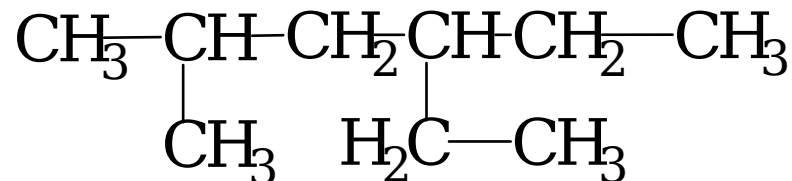
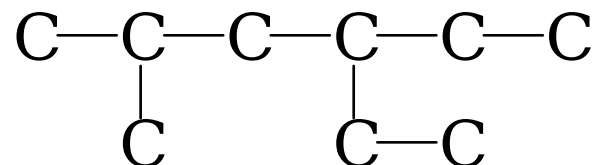
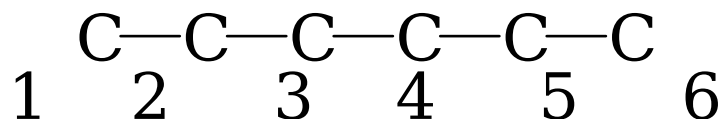
TABLE 20.9 Physical Properties of *cis*- and *trans*-1,2-Dichloroethene

Name	Structure	Space-filling Model	Density (g/mL)	Melting Point (°C)	Boiling Point (°C)
<i>cis</i> -1,2-Dichloroethene			1.284	−80.5	60.1
<i>trans</i> -1,2-Dichloroethene			1.257	−49.4	47.5

Drawing Structural Formulas

4-ethyl-2-methylhexane

- draw and number the base chain carbon skeleton
- add the carbon skeletons of each substituent on the appropriate main chain C
- add in required H's

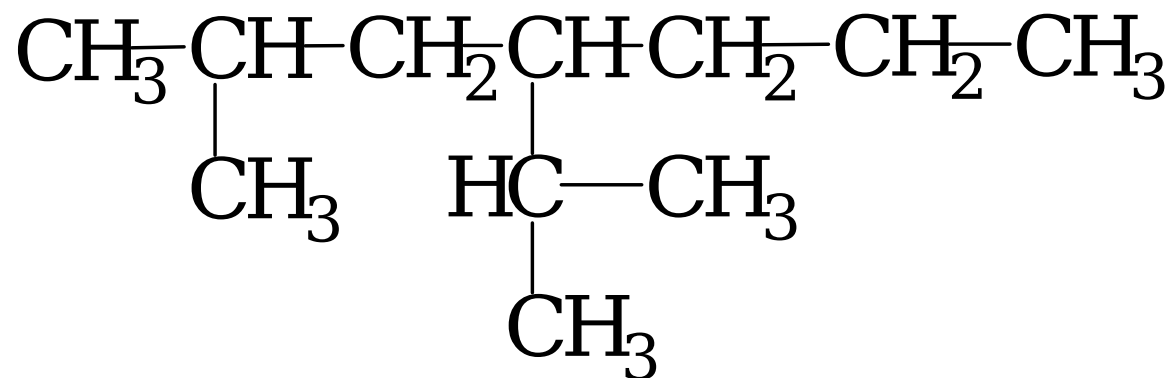


Practice – Draw the structural
formula of 4-isopropyl-2-
methylheptane

Practice – Draw the structural
formula of 4-isopropyl-2-
methylheptane

Practice – Draw the structural
formula of 4-isopropyl-2-
methylheptane

Practice – Draw the structural formula of 4-isopropyl-2-methylheptane



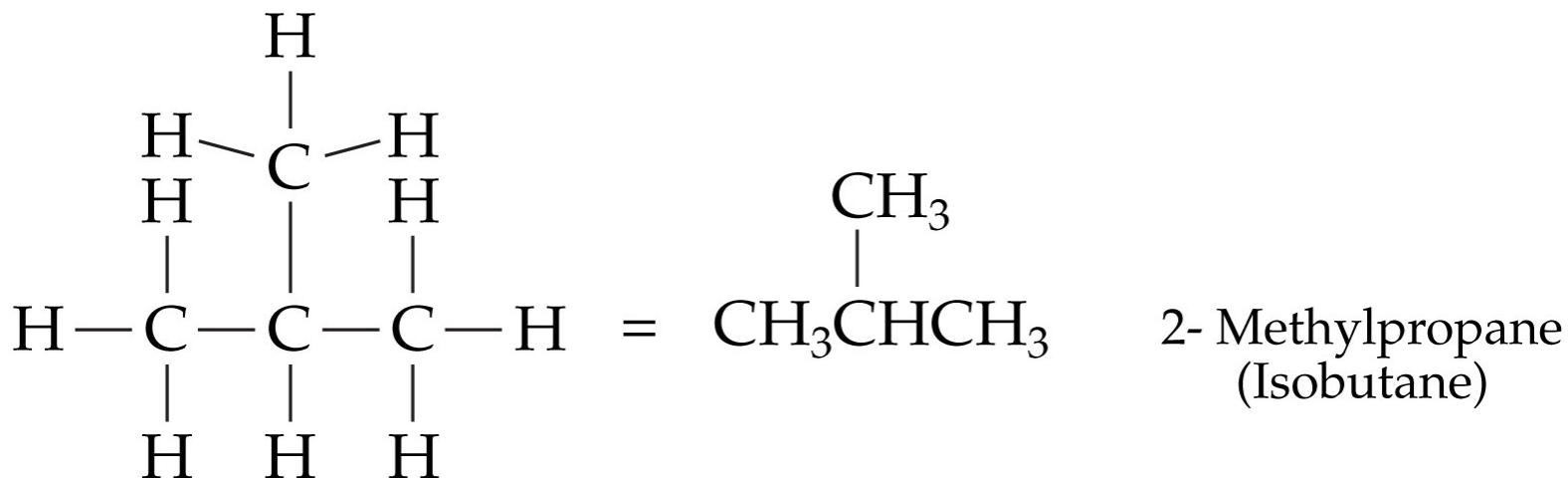
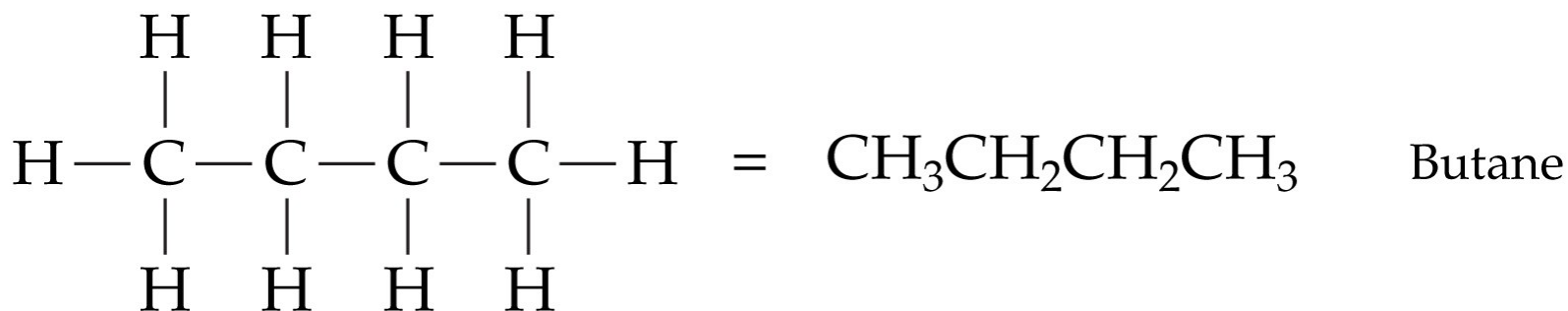
Drawing Organic Structures

Structural

Formula

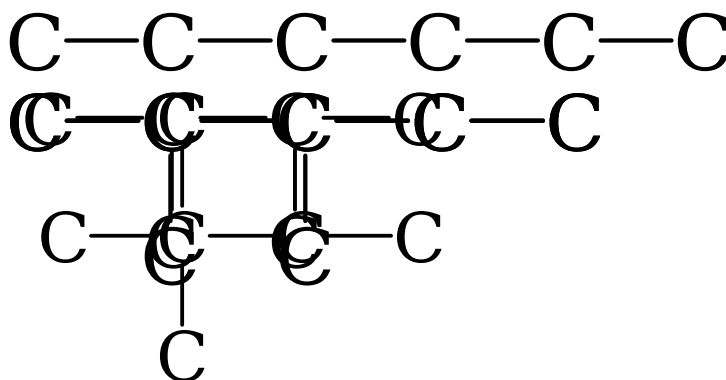
Condensed

Formula



Ex 20.1 – Write the structural formula of all isomers and carbon skeleton formula for C_6H_{14}

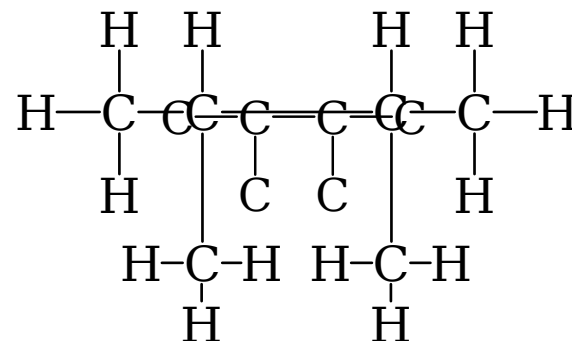
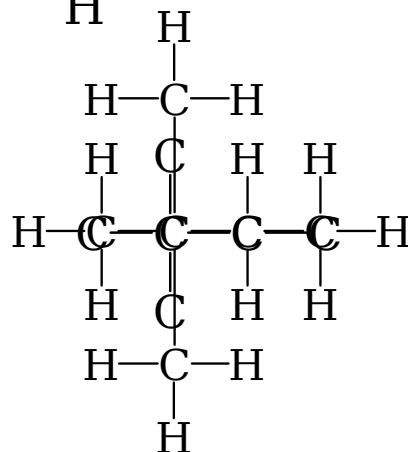
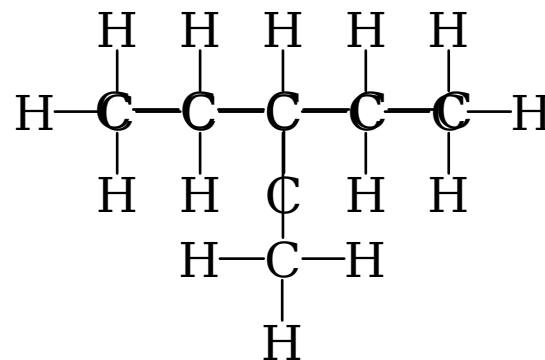
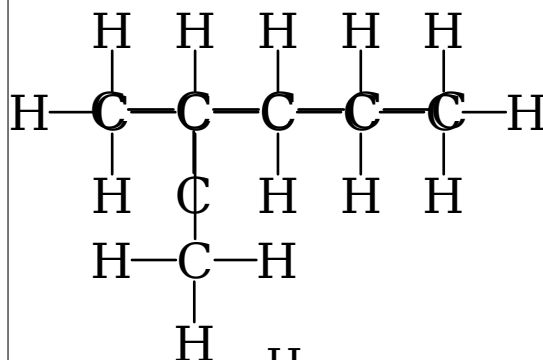
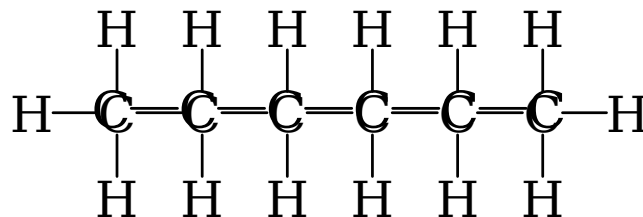
start by connecting the carbons in a line



determine the C skeleton of the other isomers

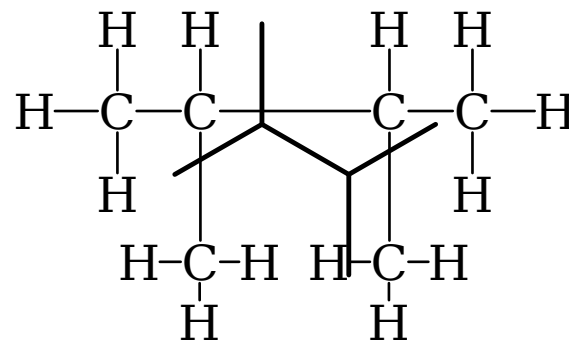
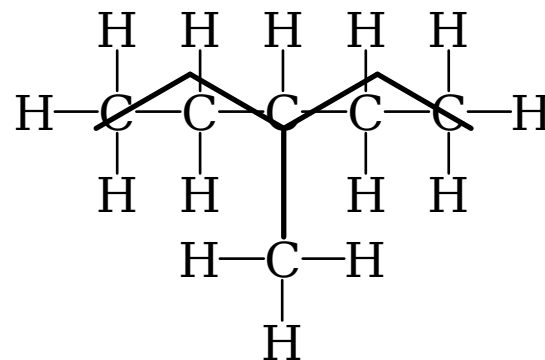
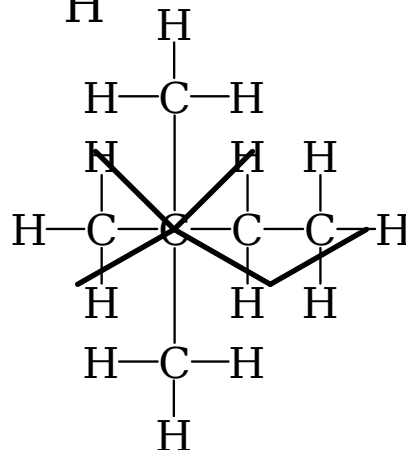
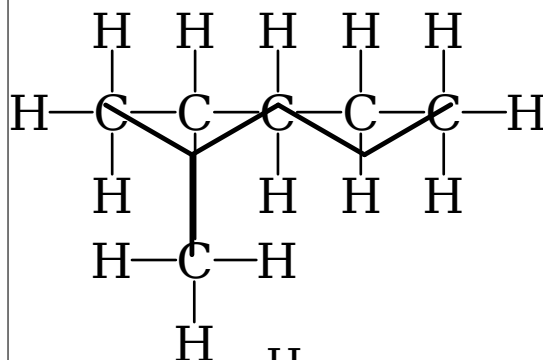
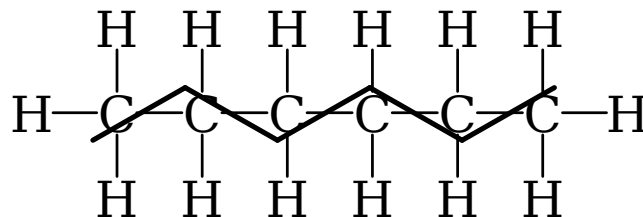
Ex 20.1 – Write the structural formula and carbon skeleton formula for C_6H_{14}

fill in the
H to give
each C 4
bonds



Ex 20.1 – Write the structural formula and carbon skeleton formula for C_6H_{14}

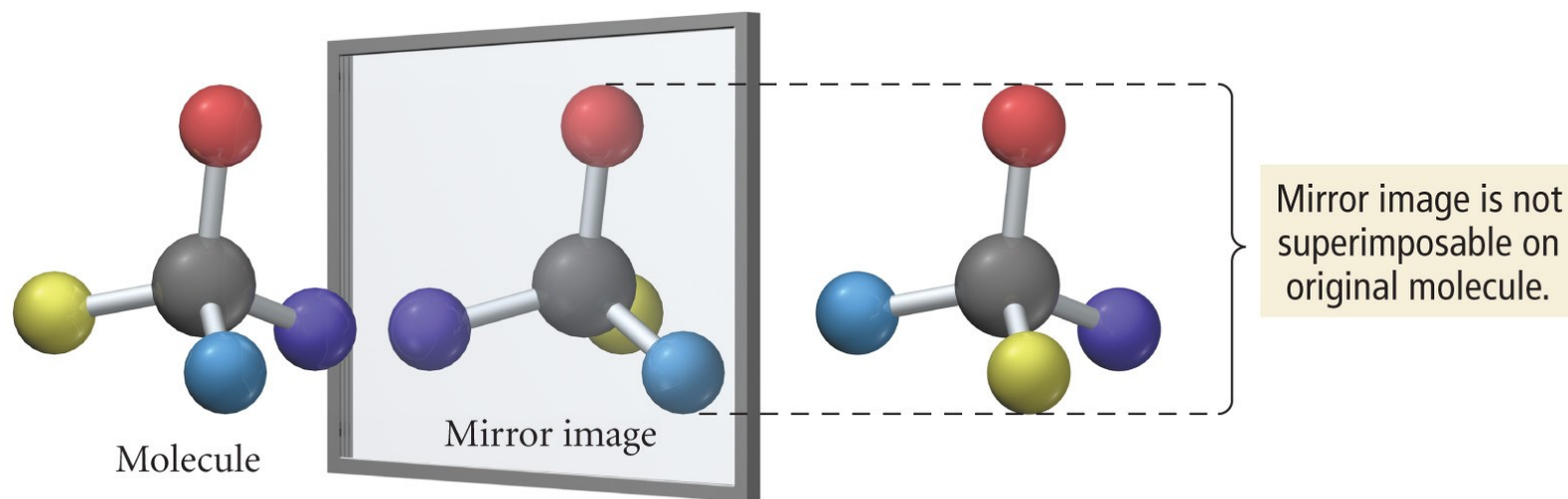
convert
each to a
carbon
skeleton
formula –
each bend
and the
ends
represent
C atoms



Stereoisomers

- **stereoisomers** are different molecules whose atoms are connected in the same order, but have a different spatial direction, they can be:
 - ✓ **optical isomers** - molecules that are non-superimposable mirror images of each other
 - ✓ **geometric isomers** - stereoisomers that are not optical isomers

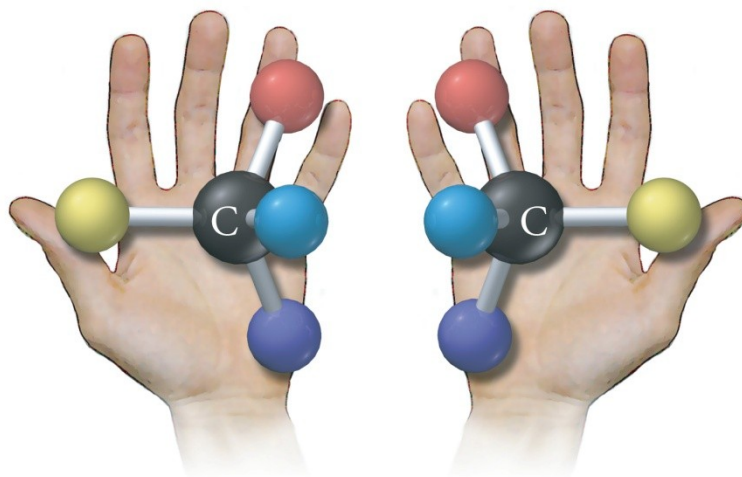
Optical Isomers - Nonsuperimposable Mirror Images



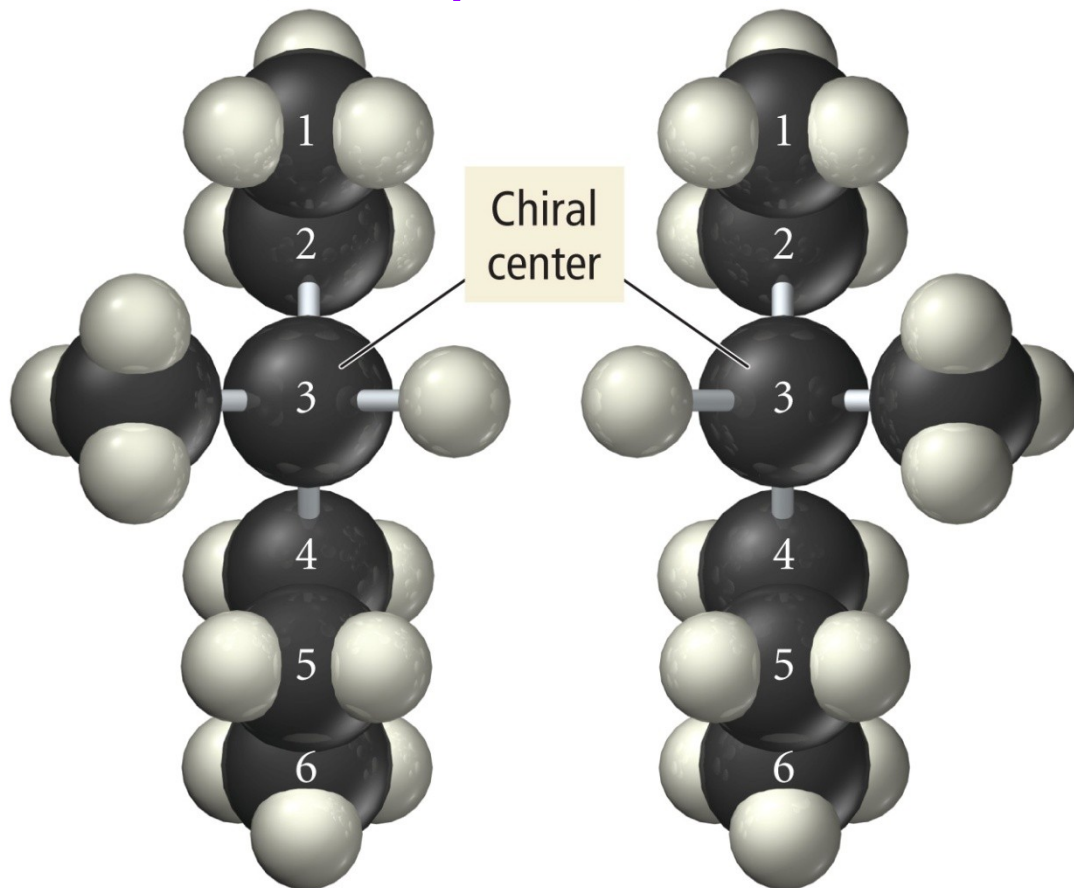
mirror image cannot be rotated so all its atoms align
with the same atoms of the original molecule

Chirality

- any molecule with a non-superimposable mirror image is said to be **chiral**
- any carbon with 4 different substituents is called a chiral center
- a pair of non-superimposable mirror images are called a pair of **enantiomers**



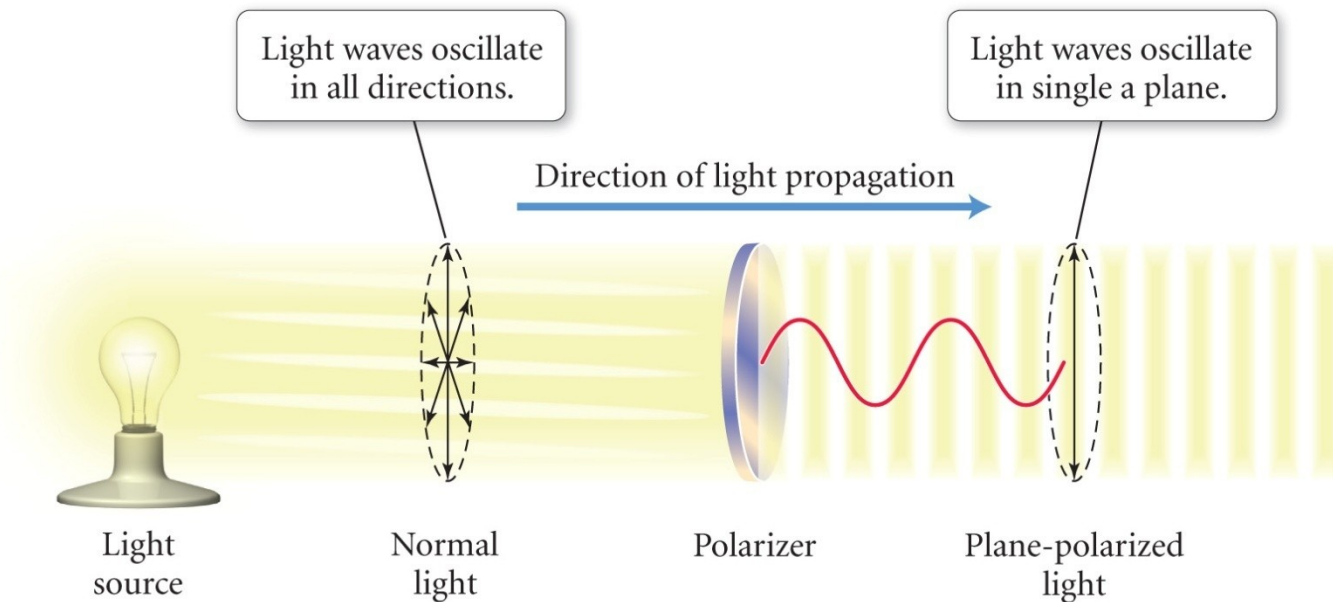
Optical Isomers of 3-methylhexane



Optical isomers of 3-methylhexane

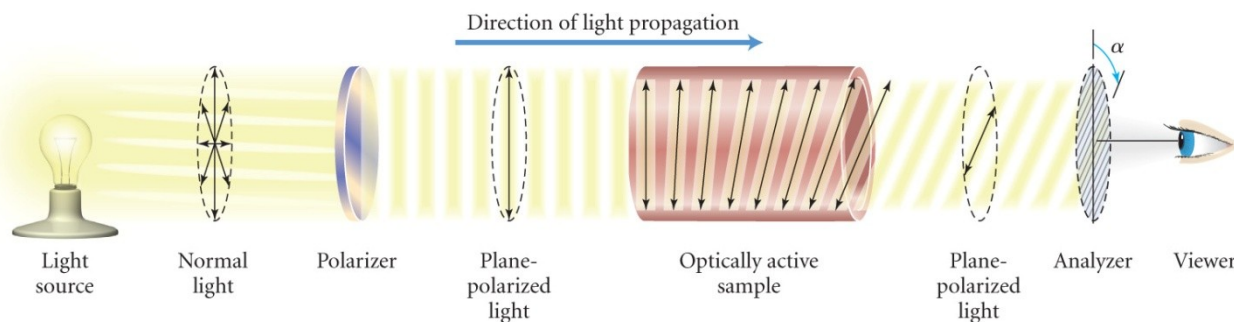
Plane Polarized Light

- light that has been filtered so that only those waves traveling in a single plane are allowed through



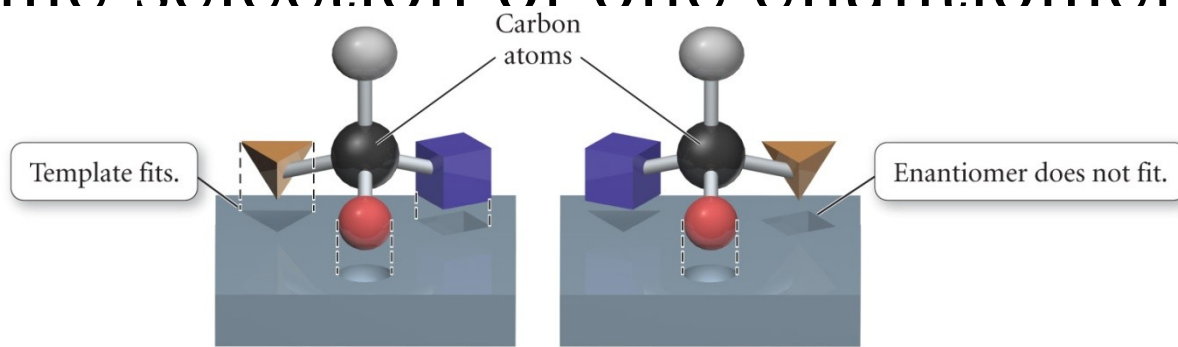
Optical Activity

- a pair of enantiomers have all the same physical properties except one – the direction they rotate the plane of plane polarized light
 - ✓ each will rotate the plane the same amount, but in opposite directions
 - ✓ dextrorotatory = rotate to the right
 - ✓ levorotatory = rotate to the left
- an equimolar mixture of the pair is called a **racemic mixture**
 - ✓ rotations cancel, so there is no net rotation of light

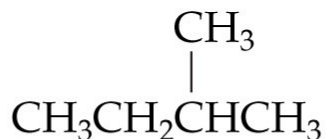
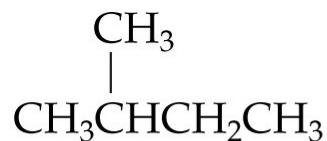


Chemical Behavior of Enantiomers

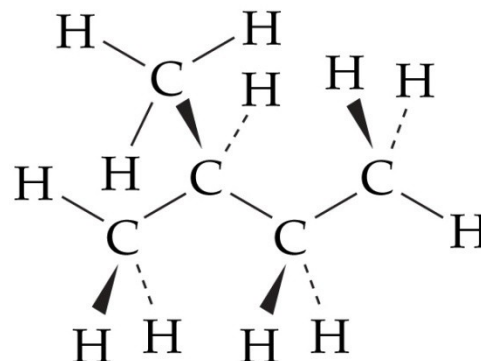
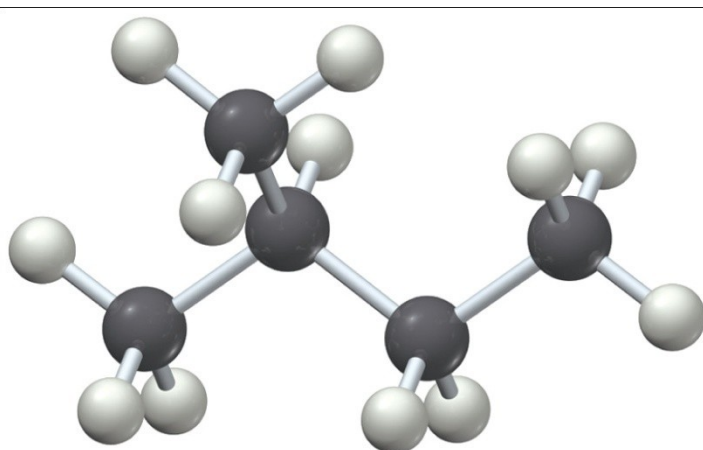
- a pair of enantiomers will have the same chemical reactivity in a non-chiral environment
- but in a chiral environment they may exhibit different behaviors
 - ✓ enzyme selection of one enantiomer of a pair



The Shapes of Organic



Some representations of 2-methylbutane



2-Methylbutane

Naming Alkanes

IUPAC Rules

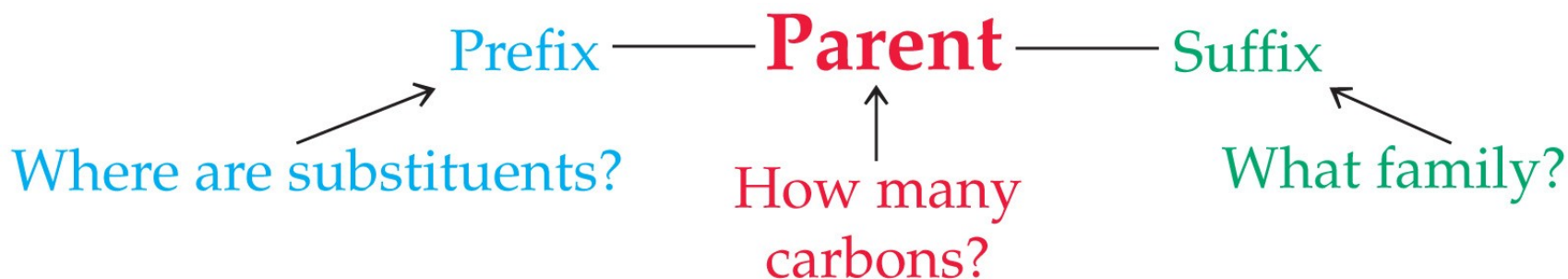


TABLE 22.1 Names of Straight-Chain Alkanes

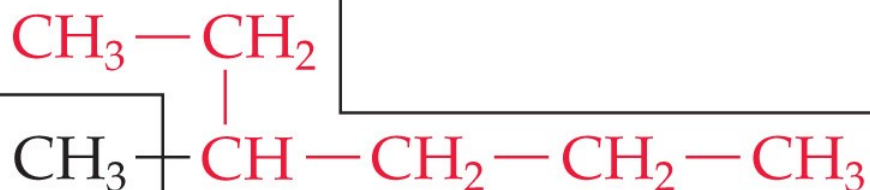
Number of Carbons	Structure	Name	Number of Carbons	Structure	Name
1	CH ₄	<i>Methane</i>	6	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	<i>Hexane</i>
2	CH ₃ CH ₃	<i>Ethane</i>	7	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	<i>Heptane</i>
3	CH ₃ CH ₂ CH ₃	<i>Propane</i>	8	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	<i>Octane</i>
4	CH ₃ CH ₂ CH ₂ CH ₃	<i>Butane</i>	9	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	<i>Nonane</i>
5	CH ₃ CH ₂ CH ₂ CH ₂ CH ₃	<i>Pentane</i>	10	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	<i>Decane</i>

-ane suffix since they are alkanes

Naming Alkanes

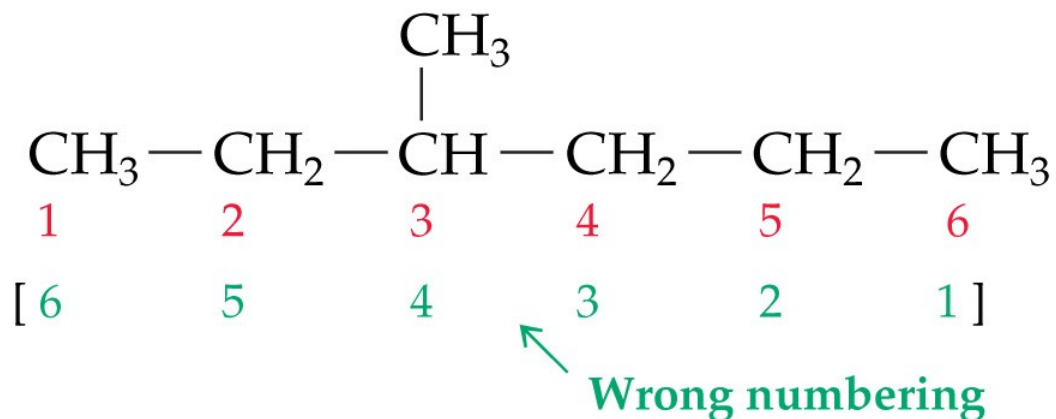
1. Name the main chain. Find the longest continuous chain of carbons in the molecule and use the name of that

Named as a hexane, not as a pentane, because the longest chain has six carbons.



Naming Alkanes

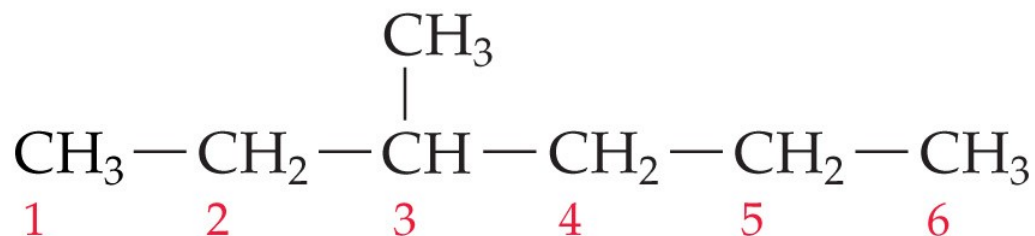
2. Number the carbon atoms in the main chain. Beginning at the end nearer the first branch point, number



The first (and only) branch occurs at the third carbon, C3, if we start numbering from the left, but would occur at C4 if we started from the right by mistake.

Naming Alkanes

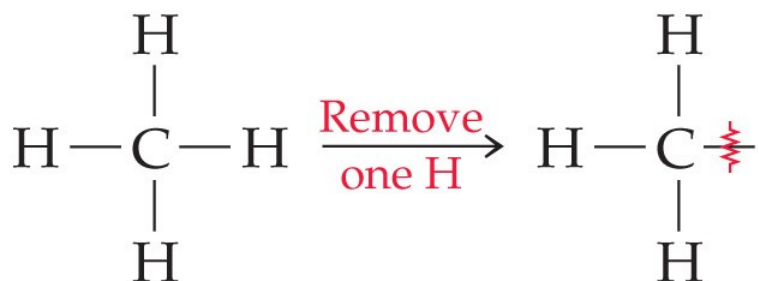
3. Identify and number the branching substituent. Assign a number to each branching substituent group on the



The main chain is a hexane. There is a $-\text{CH}_3$ substituent group connected to C3 of the chain.

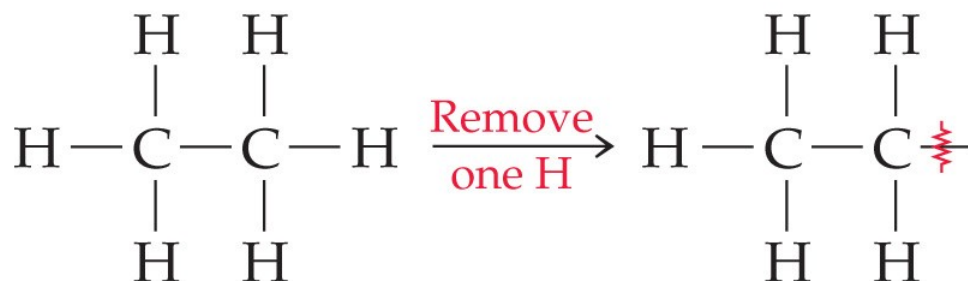
Naming Alkanes

3. Identify and number the branching substituent. Assign a number to each branching substituent group on the



Methane

A methyl group



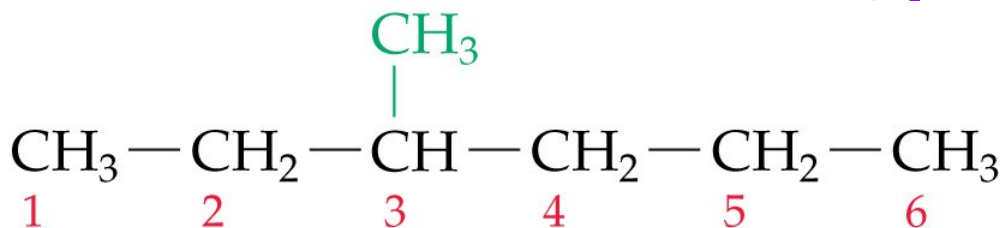
Ethane

An ethyl group

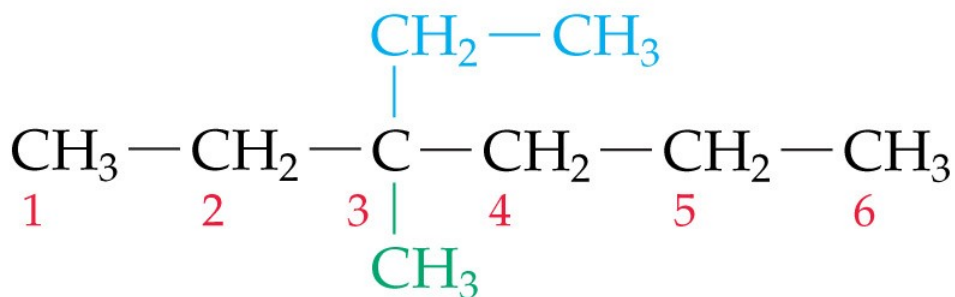
Naming Alkanes

- **Write the name as a single word.** Use hyphens to separate the different prefixes, and use commas to separate numbers when there are more than one. If two or more different substituent groups are present, list them in alphabetical order. If two or more identical substituent groups are present, use one of the Greek prefixes:

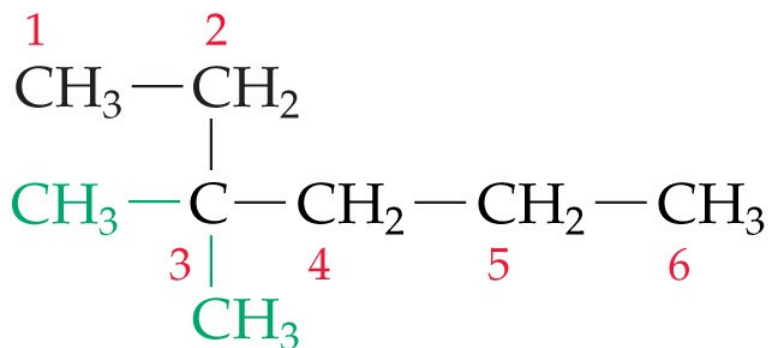
Naming Alkanes



3-Methylhexane—a six-carbon main chain with a 3-methyl substituent

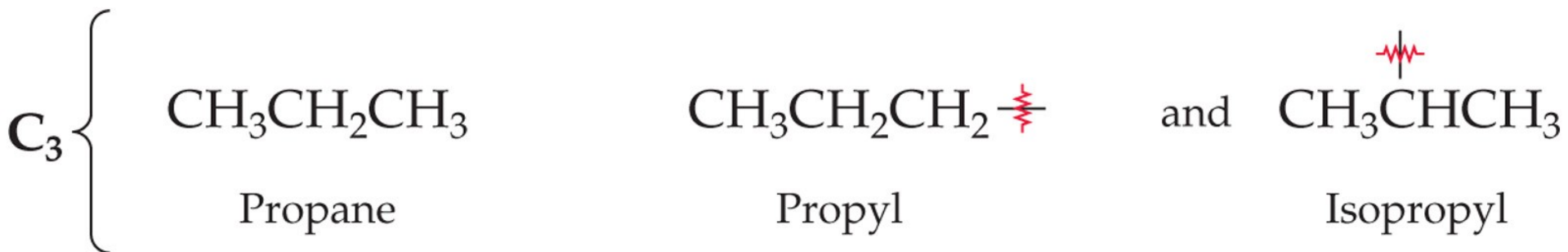


3-Ethyl-3-methylhexane—a six-carbon main chain with 3-ethyl and 3-methyl substituents

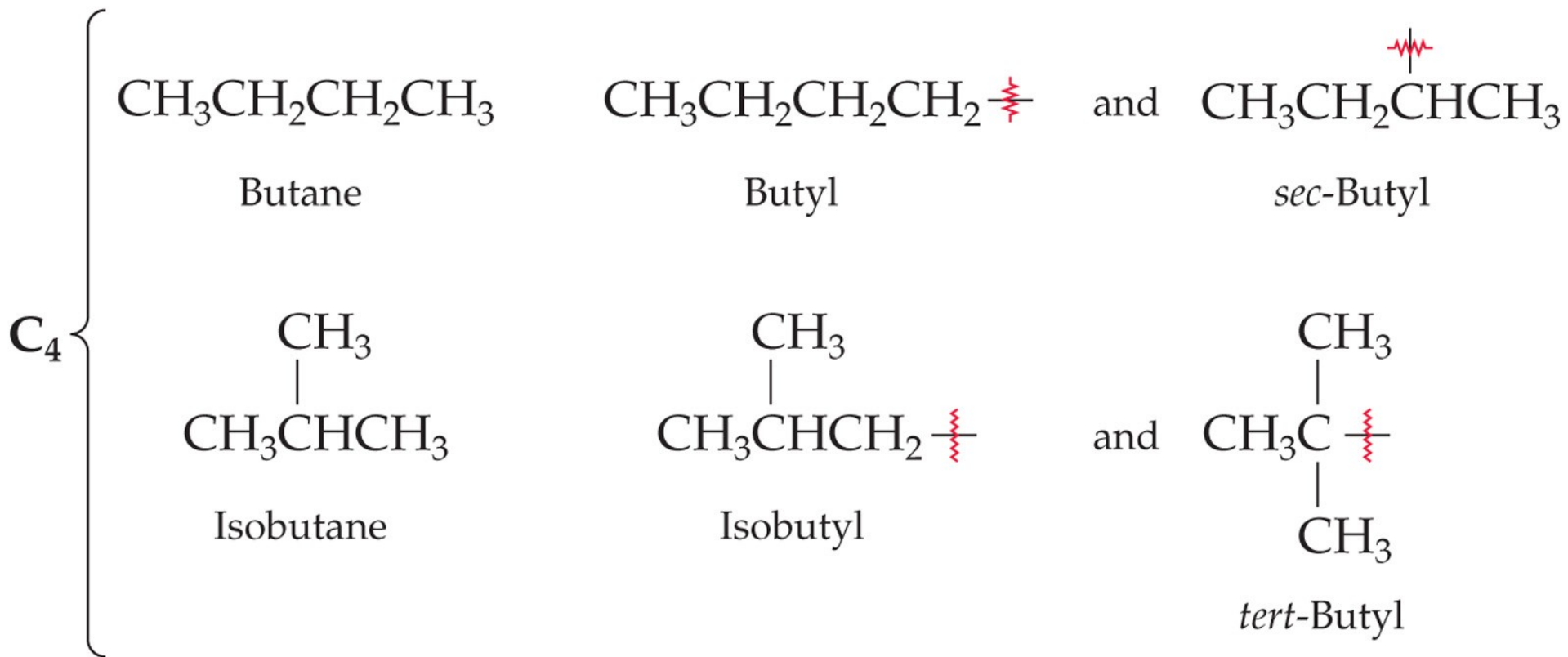


3,3-Dimethylhexane—a six-carbon main chain with two 3-methyl substituents

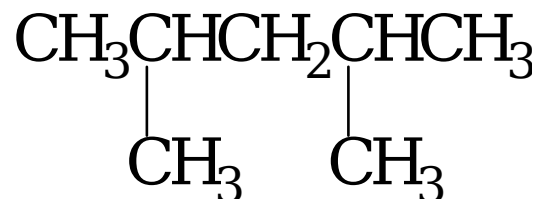
Naming Alkanes



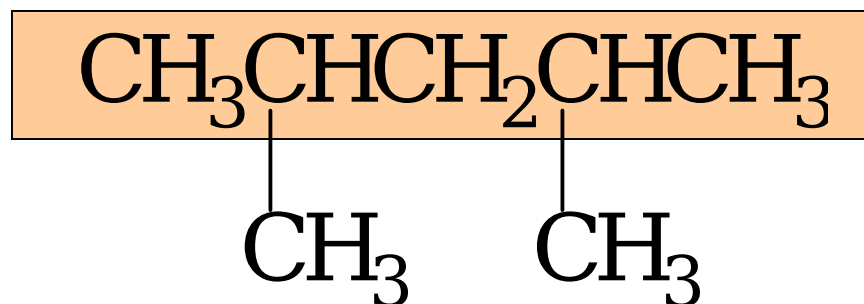
Naming Alkanes



Example - Name the alkane

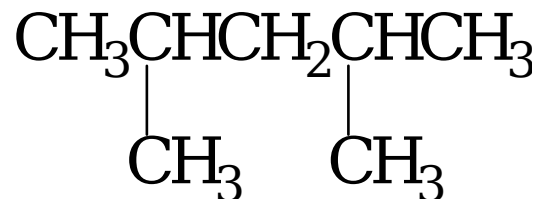


- 1) find the longest continuous C chain and use it to determine the base name

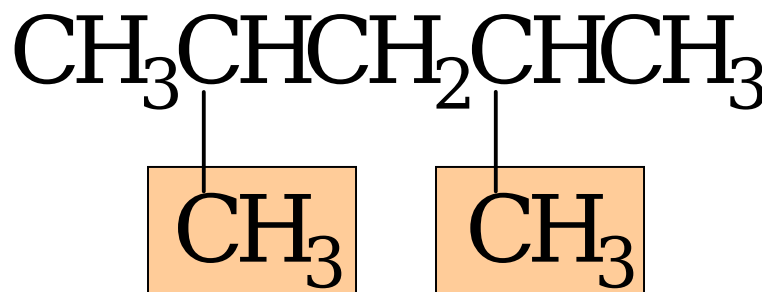


since the longest chain has 5 C
the base name is **pentane**

Example – Name the alkane



2) identify the substituent branches



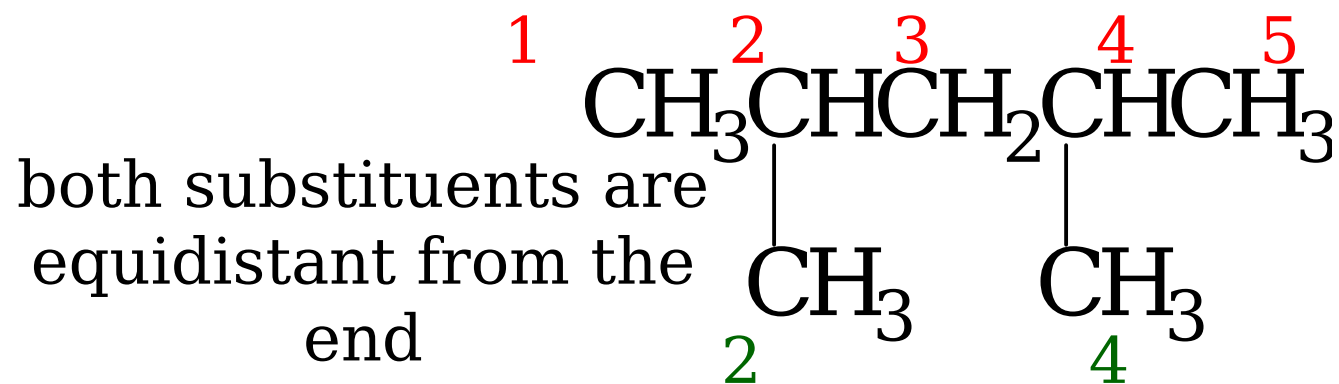
there are 2 substituents
both are 1 C chains, called **methyl**

Example - Name the alkane

3) number the chain from the end closest to a substituent branch

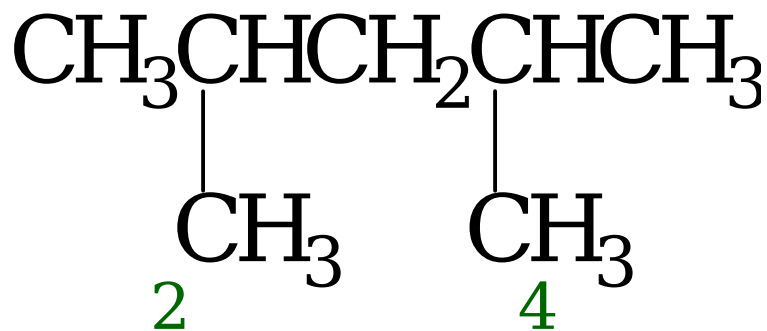
- ✓ if first substituents equidistant from end, go to next substituent in

then assign numbers to each substituent based on the number of the main chain C it's attached to



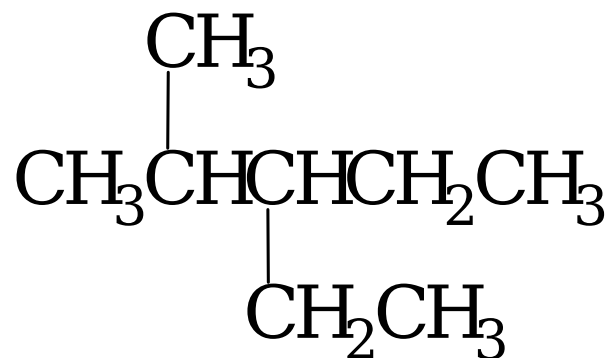
Example - Name the alkane

- 4) write the name in the following order
- 1) substituent **number** of first alphabetical substituent followed by dash
 - 2) substituent **name** of first alphabetical substituent followed by dash
 - ✓ if it's the last substituent listed, no dash
 - ✓ use prefixes to indicate multiple identical substituents
 - 3) repeat for other substituents alphabetically
 - 4) name of main chain

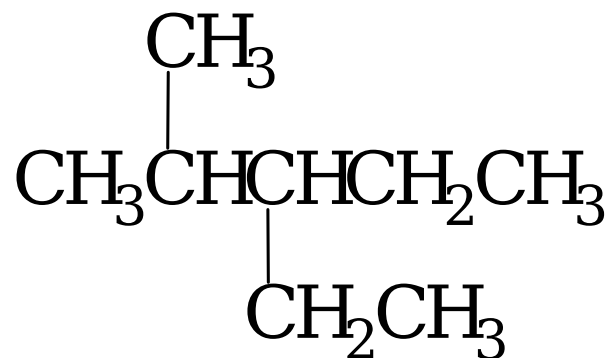


2,4 dimethylpentane

Practice – Name the Following



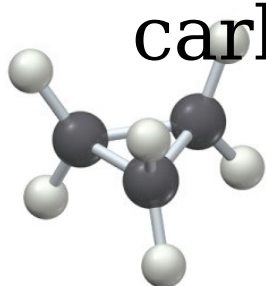
Practice – Name the Following



3-ethyl-2-methylpentane

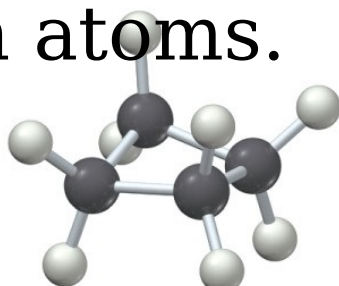
Cycloalkanes

Cycloalkane: One or more rings of carbon atoms.



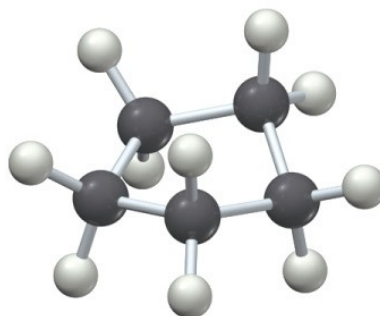
Cyclopropane

3 C



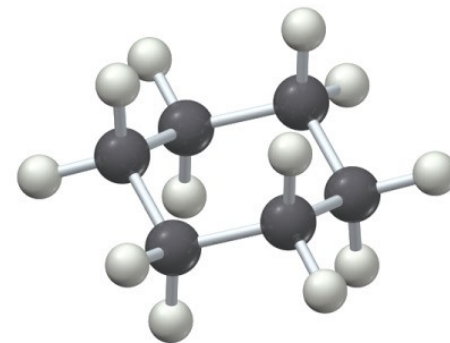
Cyclobutane

4 C



Cyclopentane

5 C

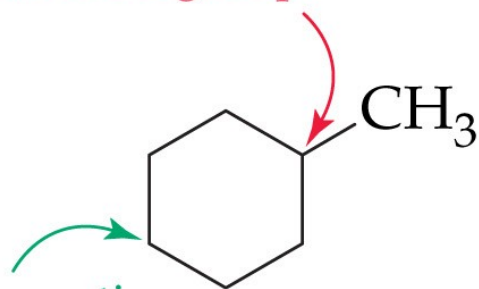


Cyclohexane

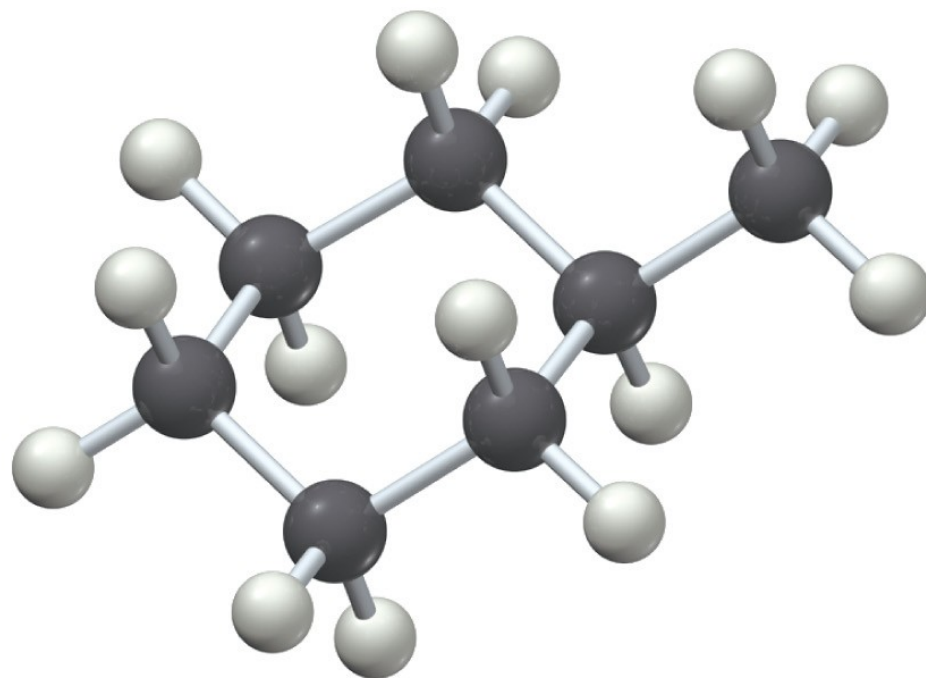
6 C

Cycloalkanes

This three-way intersection
is a CH group.

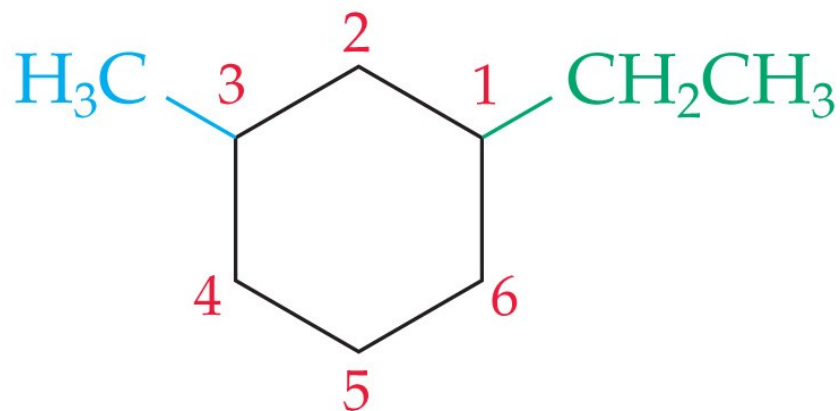


This intersection
is a CH_2 group.



Methylcyclohexane

Cycloalkanes

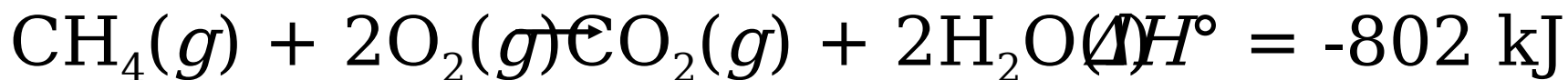


1-Ethyl-3-methylcyclohexane

Not 1-methyl-3-ethylcyclohexane
or 1-ethyl-5-methylcyclohexane
or 1-methyl-5-ethylcyclohexane

Reactions of Alkanes

Combustion:

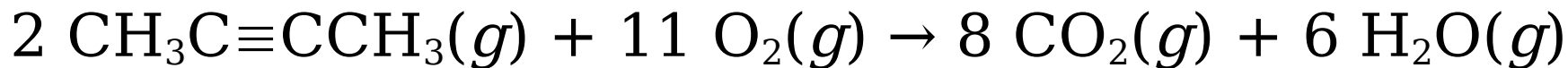
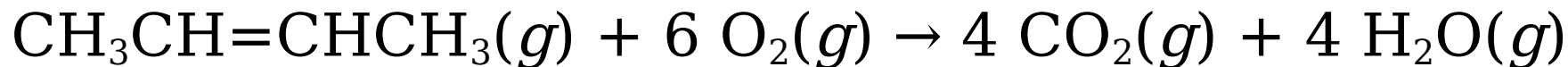
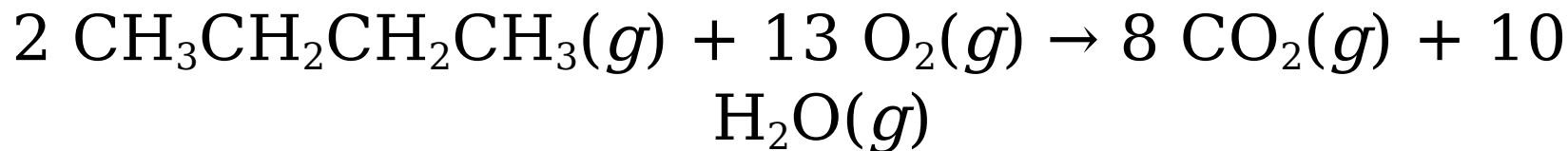


Halogens (Cl_2 or Br_2):



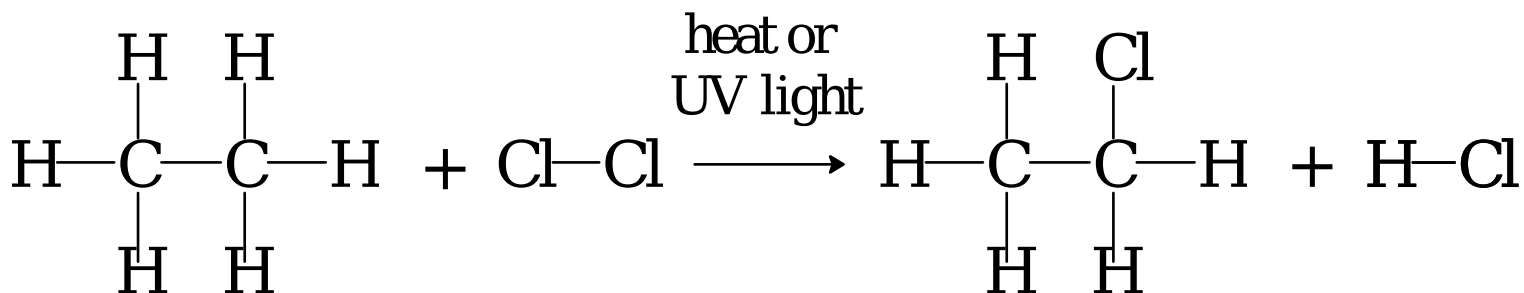
Reactions of Hydrocarbons

- all hydrocarbons undergo combustion
- combustion is always exothermic
 - ✓ about 90% of U.S. energy generated by combustion



Other Alkane Reactions

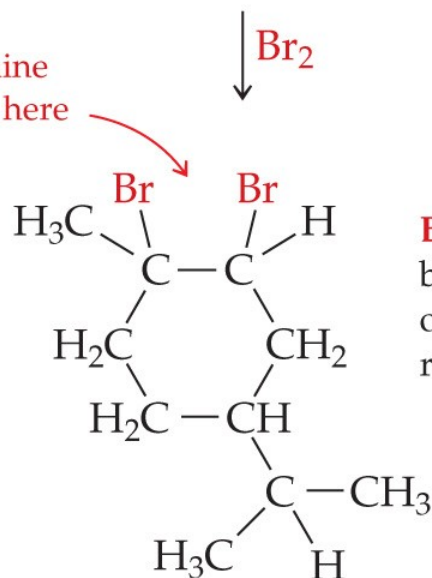
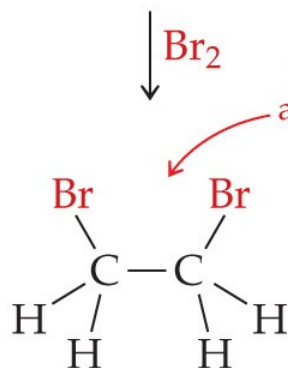
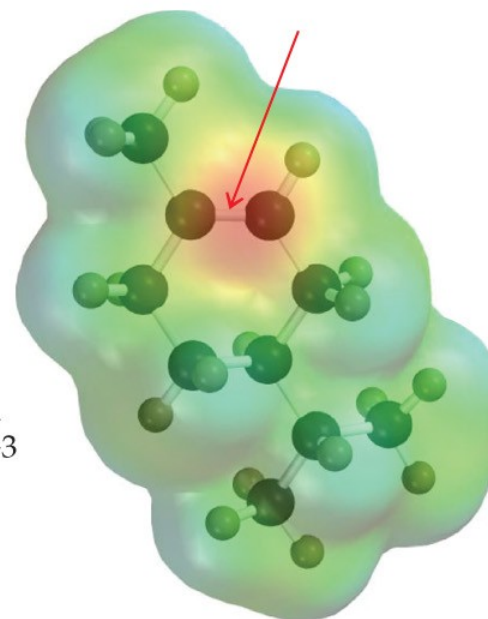
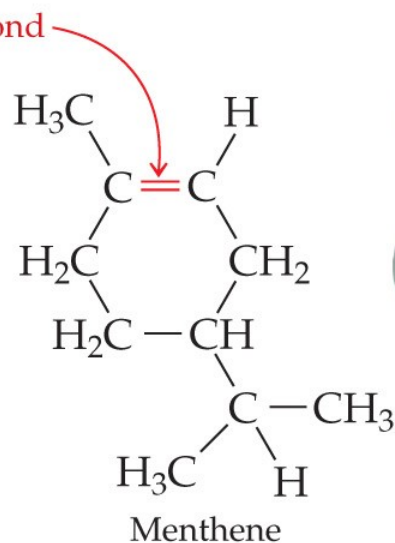
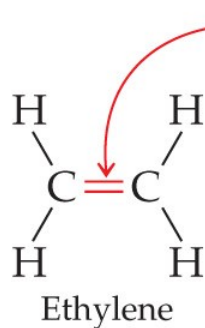
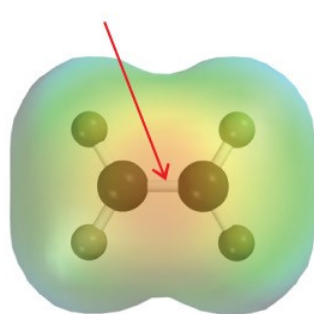
- Substitution
 - ✓ replace H with a halogen atom
 - ✓ initiated by addition of energy in the form of heat or ultraviolet light
 - to start breaking bonds
 - ✓ generally get multiple products with multiple substitutions



Families of Organic Molecules: Functional Groups

Functional Group: An atom or group of atoms within a molecule that has a characteristic chemical behavior and that undergoes the same kinds of reactions in every molecule where it occurs.

Electrostatic potential maps show similar polarity patterns for the **carbon-carbon double bond** functional group in both molecules.



Bromine therefore reacts with both in the same way, regardless of the size and complexity of the remainder of the molecule.

TABLE 22.2 Some Important Families of Organic Molecules

Family Name	Functional Group Structure	Simple Example	Name	Name Ending
Alkane	(contains only C—H and C—C single bonds)	CH ₃ CH ₃	Ethane	-ane
Alkene		H ₂ C=CH ₂	Ethene (Ethylene)	-ene
Alkyne		H—C≡C—H	Ethyne (Acetylene)	-yne
Arene (aromatic)			Benzene	None
Alcohol		CH ₃ OH	Methanol	-ol
Ether		CH ₃ OCH ₃	Dimethyl ether	ether
Amine		CH ₃ NH ₂	Methylamine	-amine
Aldehyde		CH ₃ CHO	Ethanal (Acetaldehyde)	-al
Ketone		CH ₃ COCH ₃	Propanone (Acetone)	-one
Carboxylic acid		CH ₃ COOH	Ethanoic acid (Acetic acid)	-oic acid
Ester		CH ₃ COOCH ₃	Methyl ethanoate (Methyl acetate)	-oate
Amide		CH ₃ CONH ₂	Ethanamide (Acetamide)	-amide

The bonds whose connections aren't specified are assumed to be attached to carbon or hydrogen atoms in the rest of the molecule.

Alkenes and Alkynes

Alkene: A hydrocarbon that contains a carbon-carbon double bond.

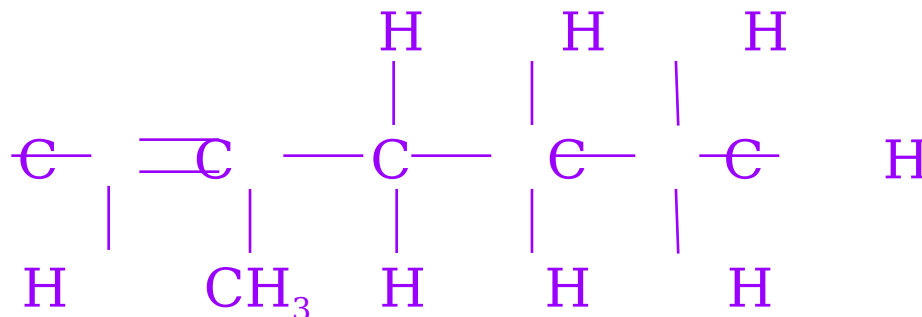
Alkyne: A hydrocarbon that contains a carbon-carbon triple bond.

Unsaturated: A hydrocarbon that contains fewer hydrogens per carbon than the related alkane.

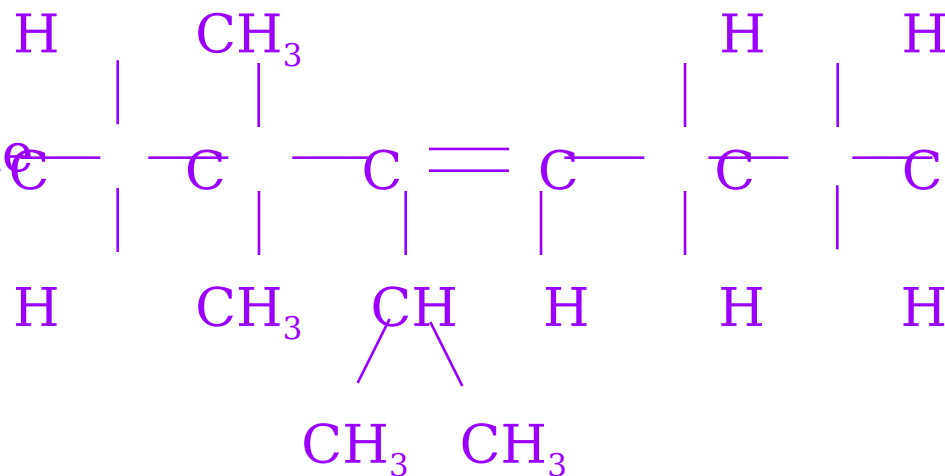
Saturated: A hydrocarbon that contains the maximum possible number of hydrogens

Examples of Naming Alkenes

2-methyl-1-pentene

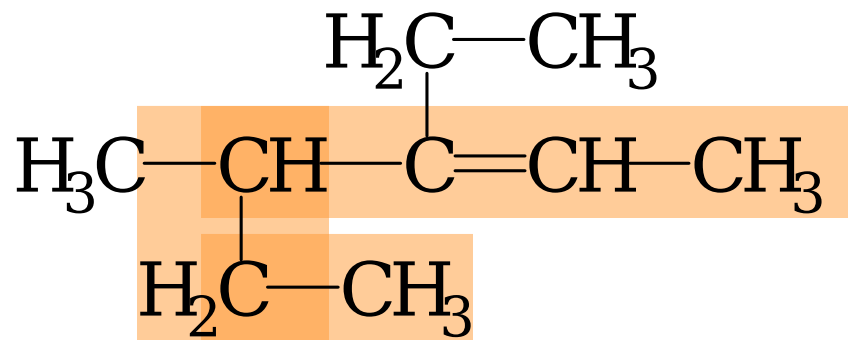


3-isopropyl-2,2-dimethyl-3-hexene



Name the Alkene

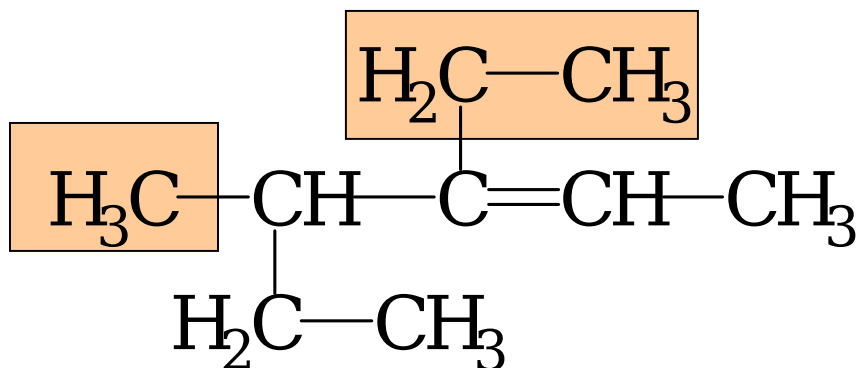
- 1) find the longest, continuous C chain that contains the double bond and use it to determine the base name



Since the longest chain with the double bond has 6 C
the base name is **hexene**

Name the Alkene

2) identify the substituent branches



there are 2 substituents

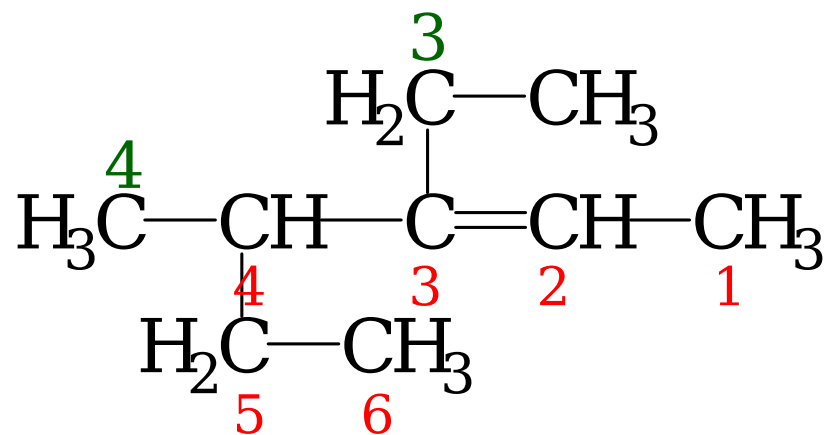
one is a 1 C chain, called **methyl**

the other one is a 2 C chain, called **ethyl**

Name the Alkene

3) number the chain from the end closest to the double bond

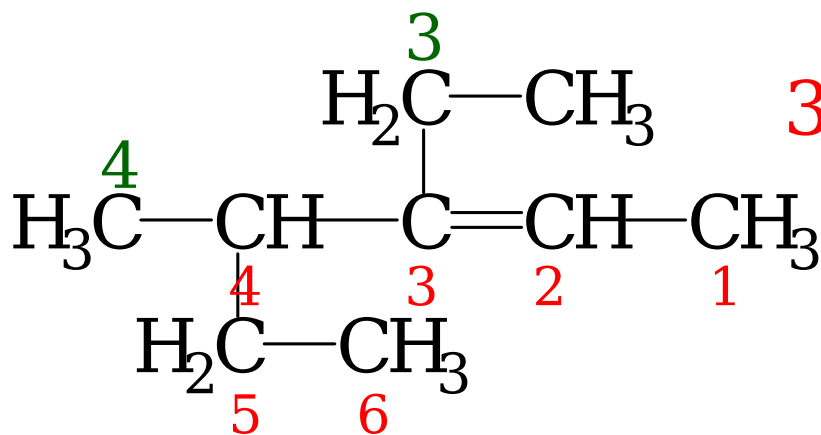
then assign numbers to each substituent based on the number of the main chain C it's attached to



Name the Alkene

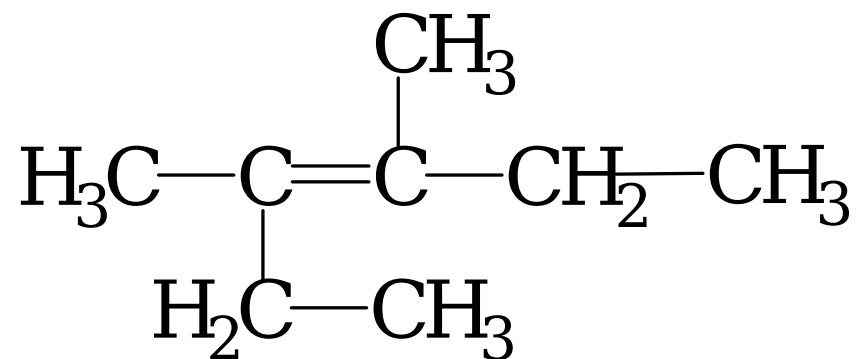
4) write the name in the following order

- 1) substituent number of first alphabetical substituent -
substituent name of first alphabetical substituent -
✓ use prefixes to indicate multiple identical substituents
- 2) repeat for other substituents
- 3) number of first C in double bond - name of main chain

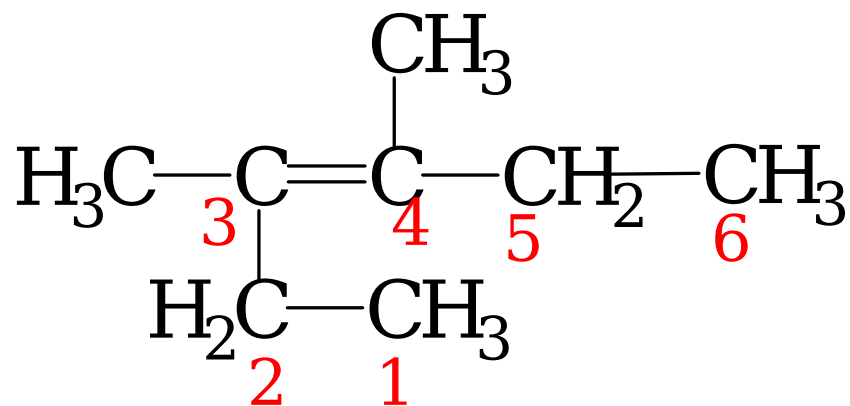


3-ethyl4-methyl2-hexene

Practice – Name the Following



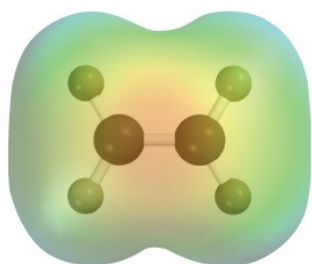
Practice – Name the Following



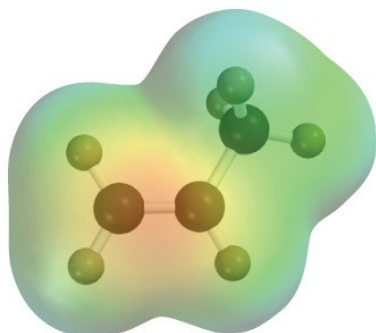
3,4-dimethyl-3-hexene

Alkenes and Alkynes

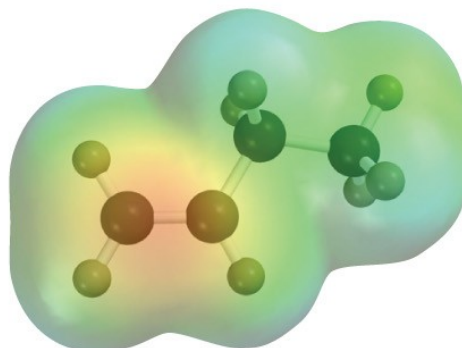
Alkenes



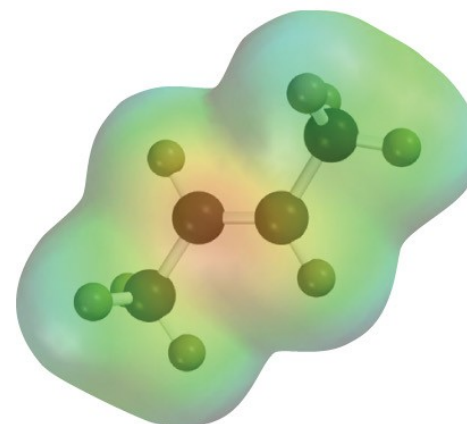
$\text{H}_2\text{C}=\text{CH}_2$
Ethylene
(ethene)



$\text{H}_2\text{C}=\text{CHCH}_3$
Propylene
(propene)



$\text{H}_2\text{C}=\text{CHCH}_2\text{CH}_3$
1-Butene

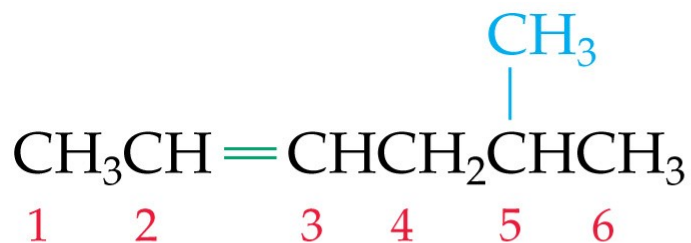


$\text{CH}_3\text{CH}=\text{CHCH}_3$
2-Butene

-ene suffix since they are alkenes

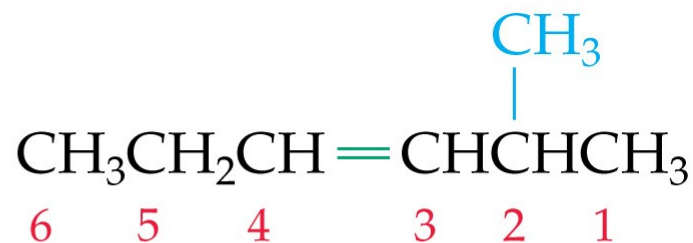
Alkenes and Alkynes

Alkenes and Isomers



5-Methyl-2-hexene

(numbered to give double bond the lower number)

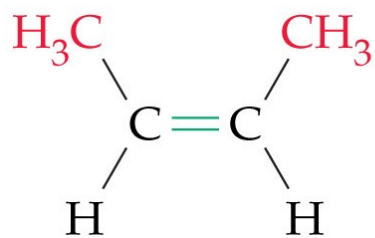


2-Methyl-3-hexene

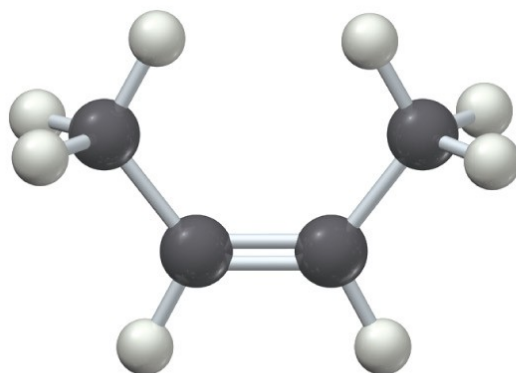
(numbered to give substituent the lower number when the double bond is equidistant from both ends)

Alkenes and Alkynes

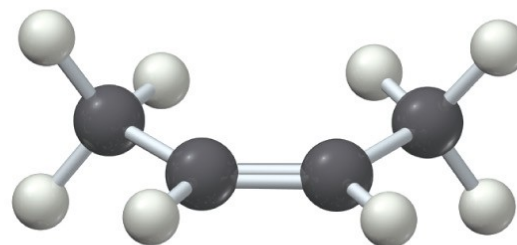
Alkenes and Isomers



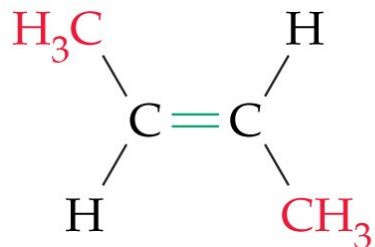
cis-2-Butene
(methyl groups on
the same side)



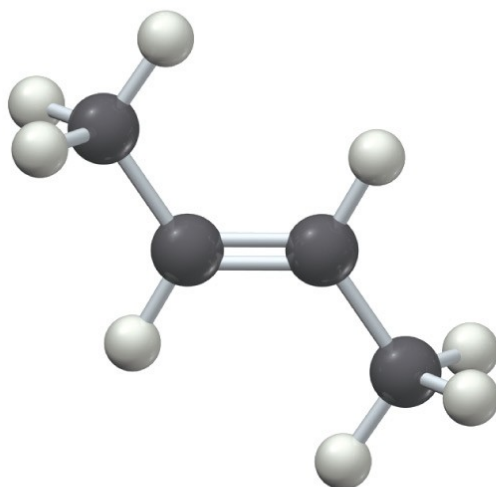
(Top view)



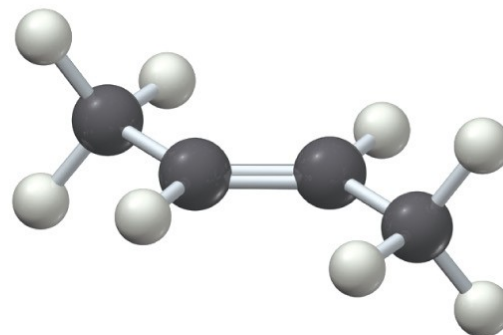
(Side view)



trans-2-Butene
(methyl groups on
opposite sides)



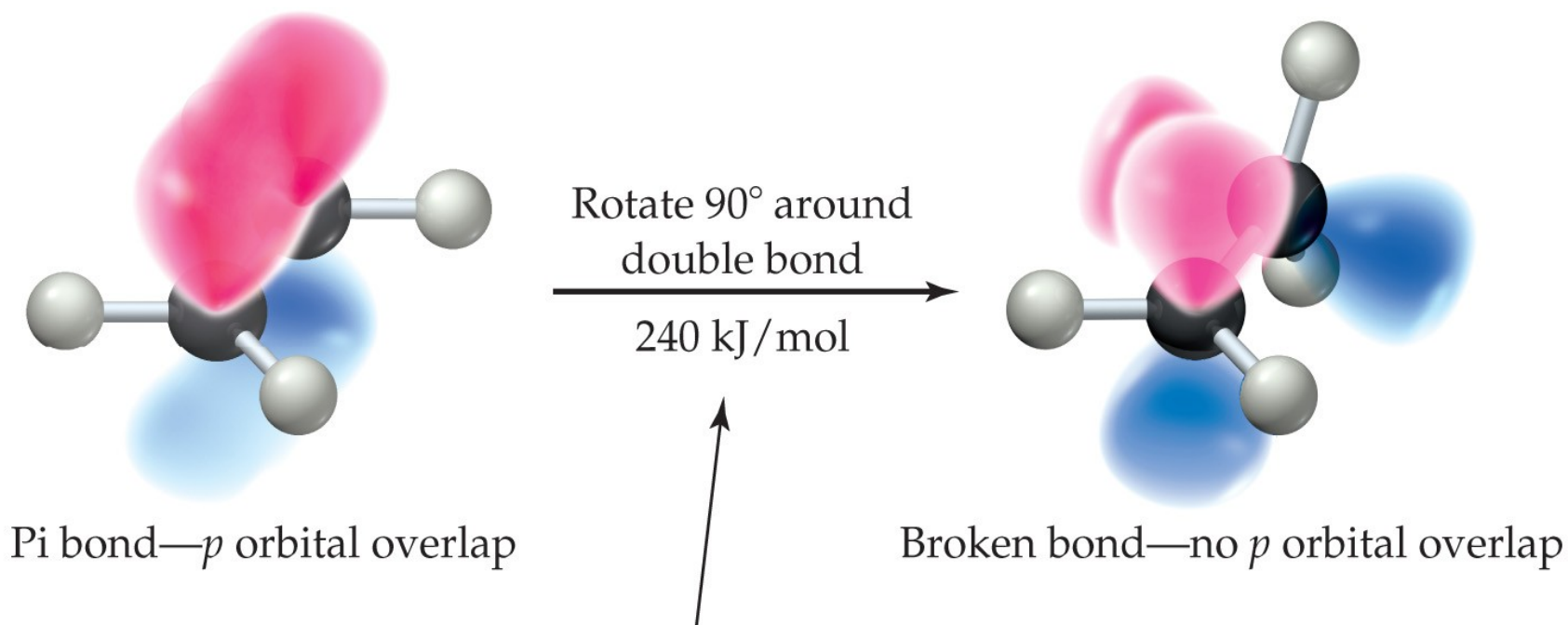
(Top view)



(Side view)

Alkenes and Alkynes

Alkenes and Isomers



A large amount of energy is required because ***p* orbital overlap** is destroyed. Cis–trans alkene isomers are stable and do not interchange because of this barrier to rotation.

Alkenes and Alkynes

Alkynes



Ethyne
(Acetylene)



Propyne



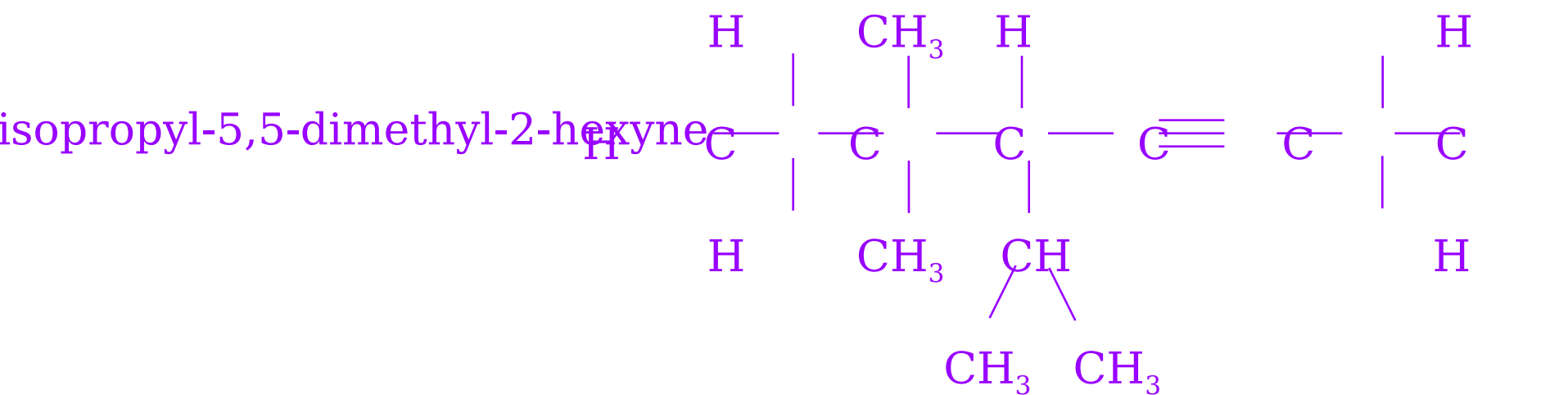
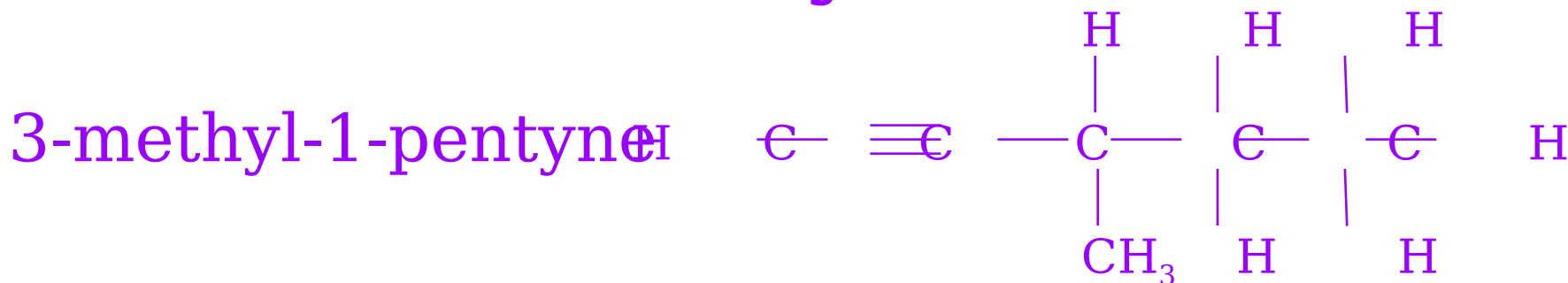
2-Butyne



1-Butyne

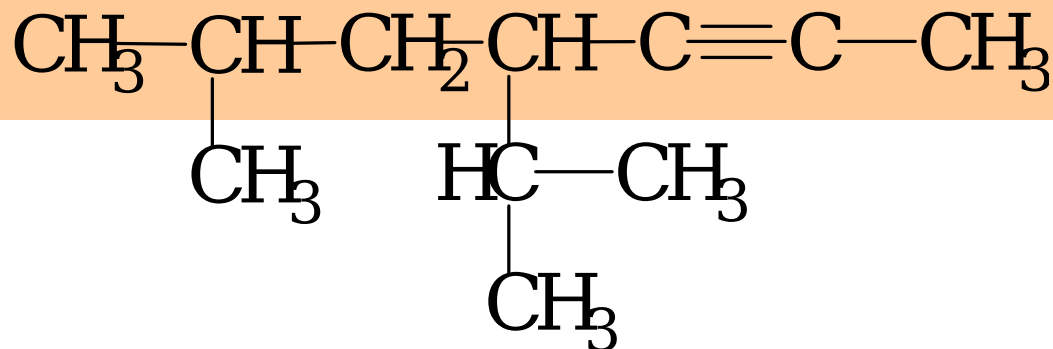
-yne suffix since they are alkynes

Examples of Naming Alkynes



Name the Alkyne

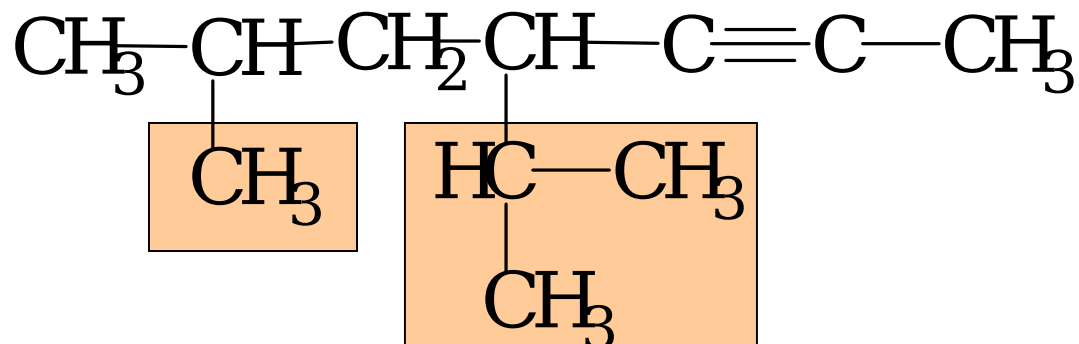
- 1) find the longest, continuous C chain that contains the triple bond and use it to determine the base name



since the longest chain with the triple bond has 7
the base name is **heptyne**

Name the Alkyne

2) identify the substituent branches



there are 2 substituents

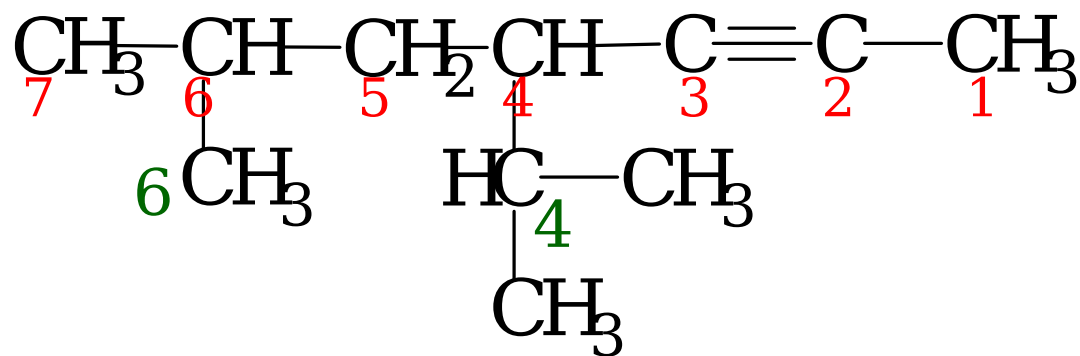
one is a 1 C chain, called **methyl**

the other one is called **isopropyl**

Name the Alkyne

3) number the chain from the end closest to the triple bond

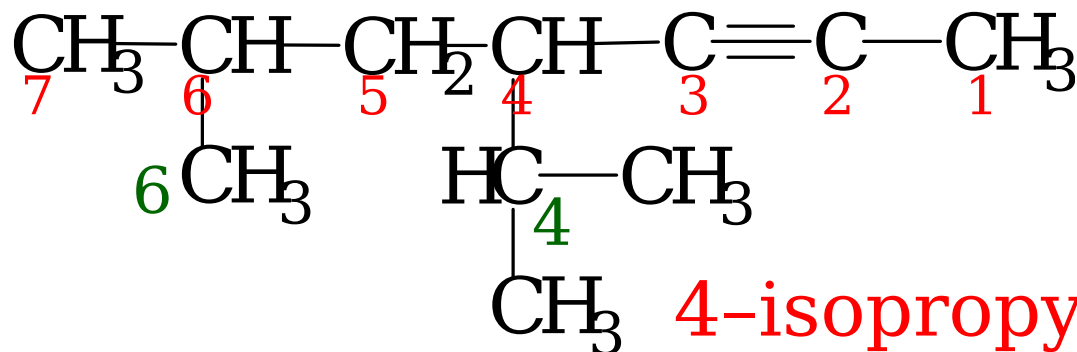
then assign numbers to each substituent based on the number of the main chain C it's attached to



Name the Alkyne

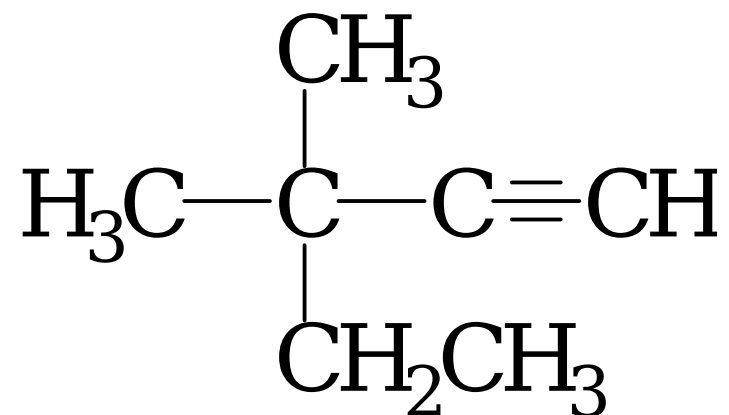
4) write the name in the following order

- 1) substituent number of first alphabetical substituent -
substituent name of first alphabetical substituent -
✓ use prefixes to indicate multiple identical substituents
- 2) repeat for other substituents
- 3) number of first C in double bond - name of main chain

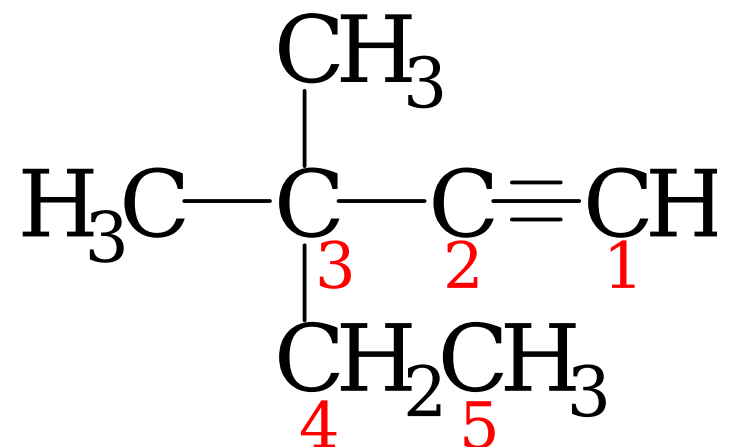


4-isopropyl-6-methyl-2-heptyne

Practice – Name the Following

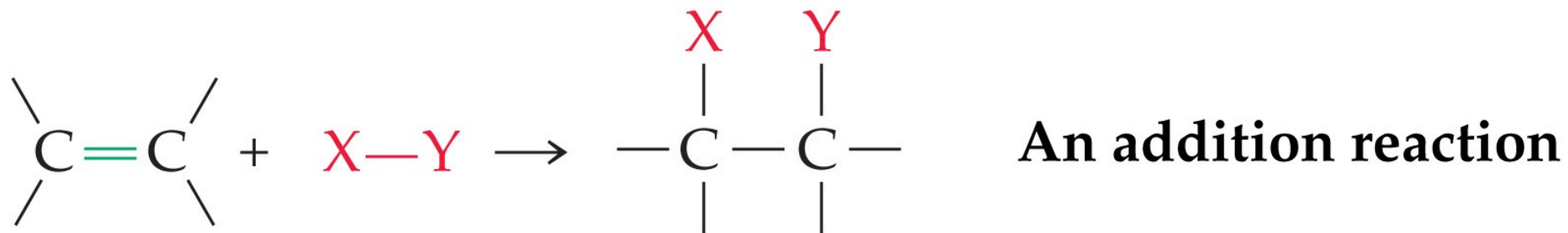


Practice - Name the Following

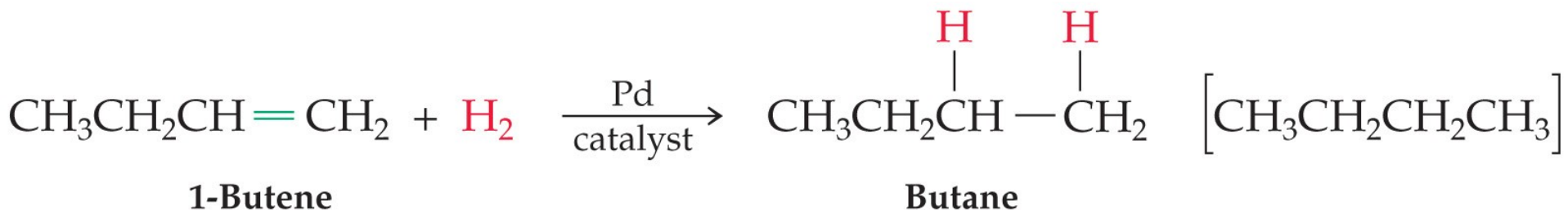


3,3-dimethyl-1-pentyne

Reactions of Alkenes



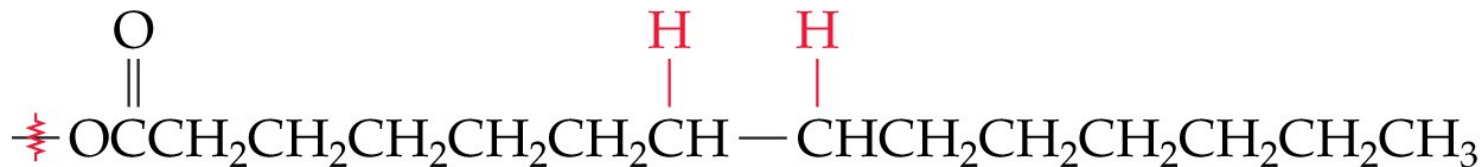
- Addition of Hydrogen:**



Reactions of Alkenes



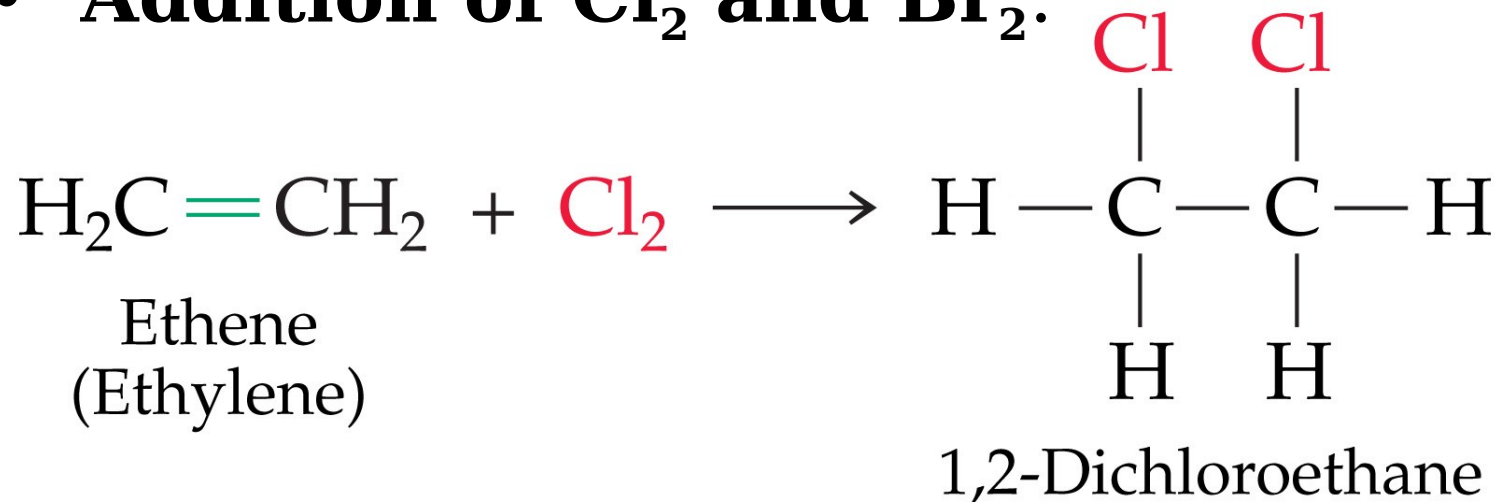
Partial structure
of a vegetable oil



Partial structure
of a saturated
cooking fat

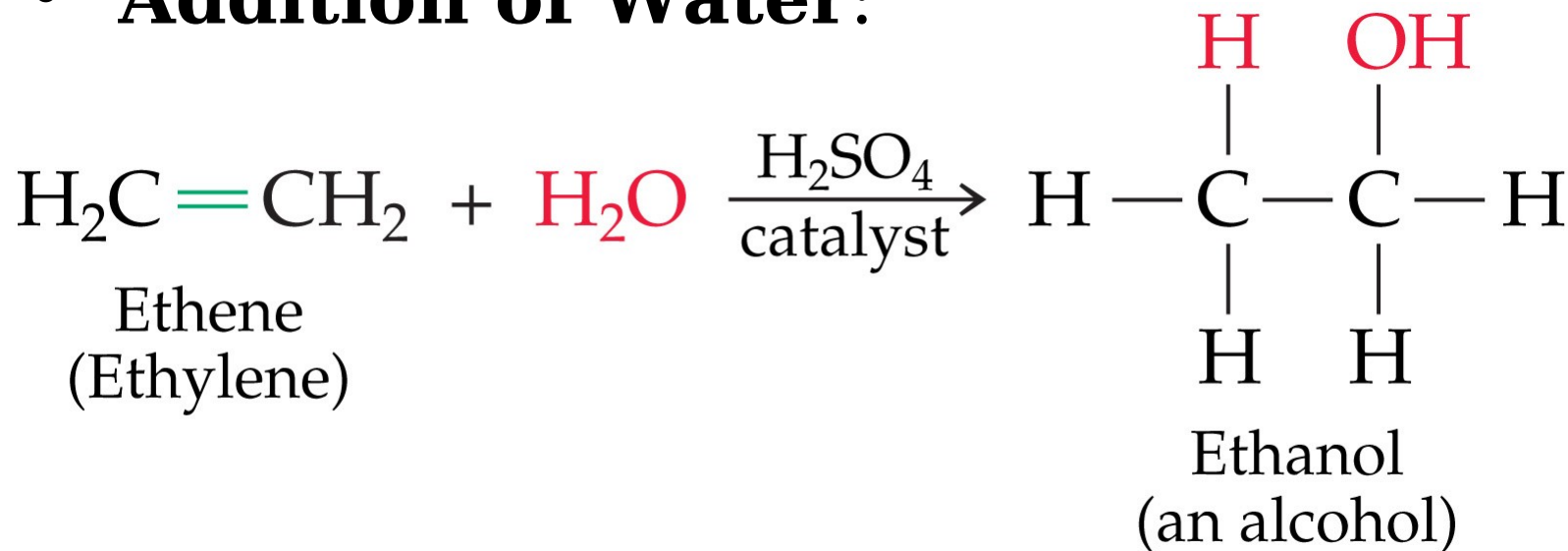
Reactions of Alkenes

- **Addition of Cl_2 and Br_2 :**



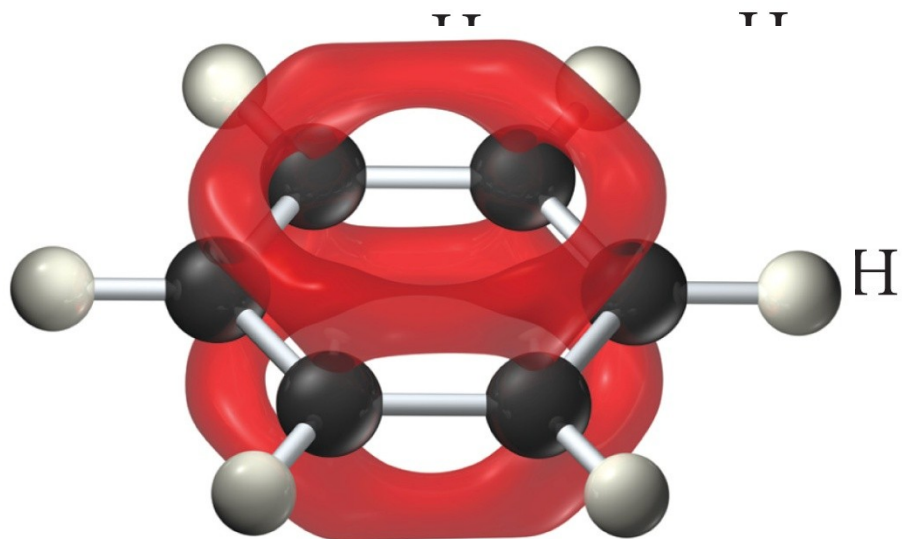
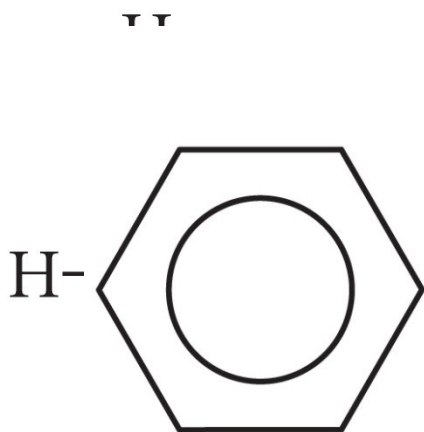
Reactions of Alkenes

- **Addition of Water:**



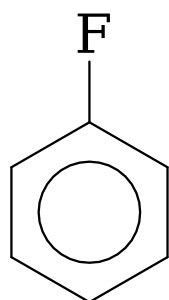
Resonance Hybrid

- the true structure of benzene is a resonance hybrid of two structures

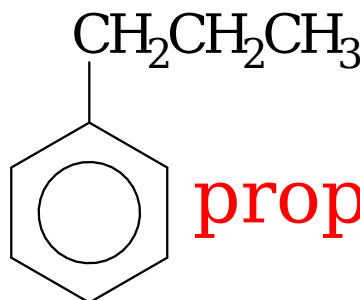


Naming Monosubstituted Benzene Derivatives

- (name of substituent)benzene
 - ✓ halogen substituent = change ending to "o"

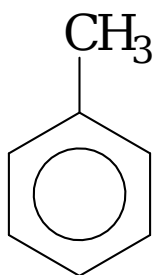


fluorobenzene

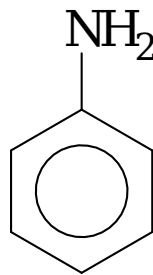


propylbenzene

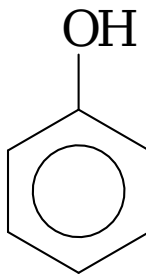
- or name of a common derivative



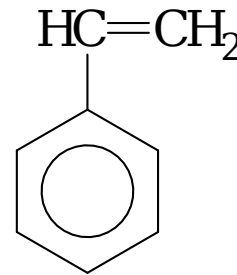
toluene



aniline



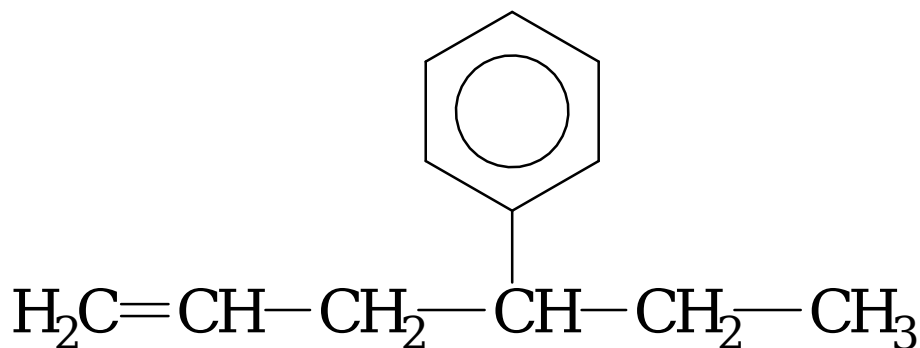
phenol



styrene

Naming Benzene as a Substituent

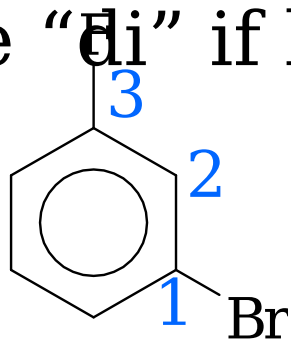
- when the benzene ring is not the base name, it is called a **phenyl** group



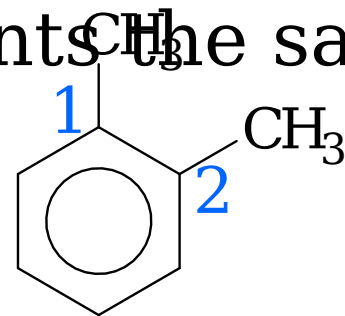
4-phenyl-1-hexene

Naming Disubstituted Benzene Derivatives

- number the ring starting at attachment for first substituent, then move toward second
 - ✓ order substituents alphabetically
 - ✓ use “di” if both substituents the same



1-bromo-3-fluorobenzene

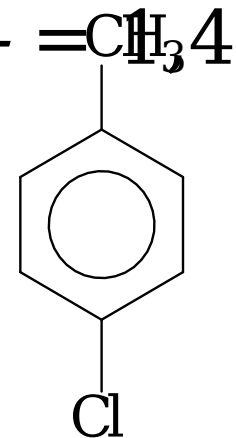
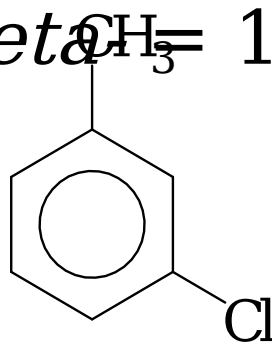
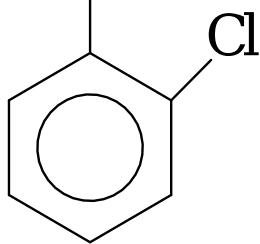


1,2-dimethylbenzene

Naming Disubstituted Benzene Derivatives

- alternatively, use relative position prefix

✓ *ortho-* = 1,2; *meta-* = 1,3; *para-* = 1,4



2-chlorotoluene

3-chlorotoluene

4-chlorotoluene

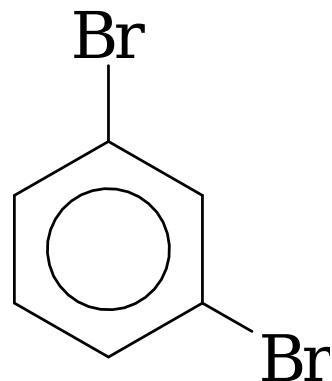
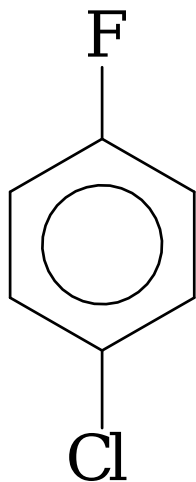
ortho-chlorotoluene *meta*-chlorotoluene *para*-chlorotoluene

o-chlorotoluene

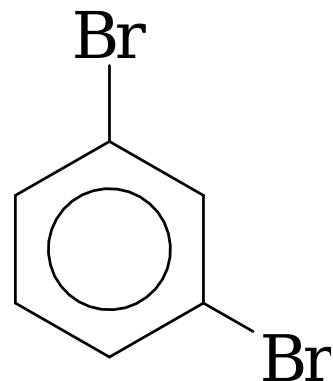
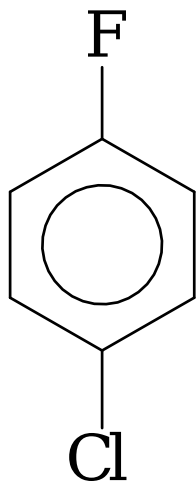
m-chlorotoluene

p-chlorotoluene

Practice – Name the Following



Practice – Name the Following



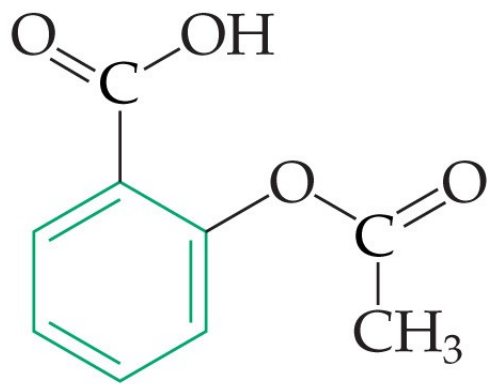
1-chloro-4-fluorobenzene
1,3-dibromobenzene
or *meta*-dibromobenzene
or *m*-dibromobenzene

Aromatic Compounds and Their Reactions

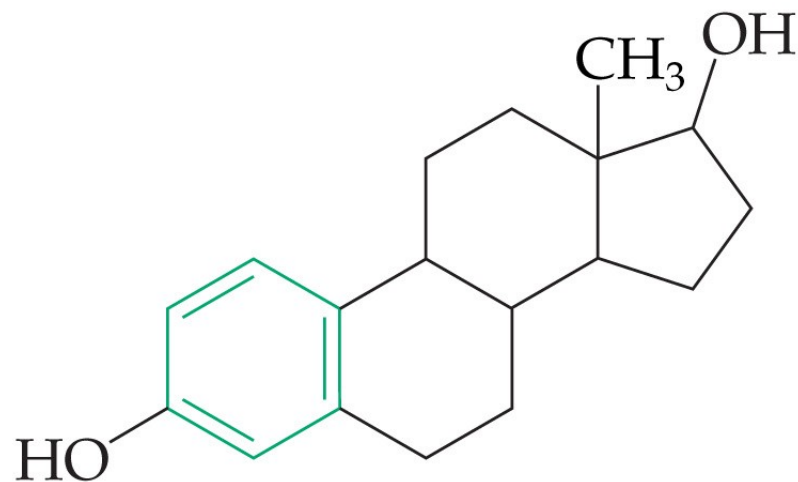
Aromatic: A class of compounds that contain a six-membered ring with three double bonds



Benzene



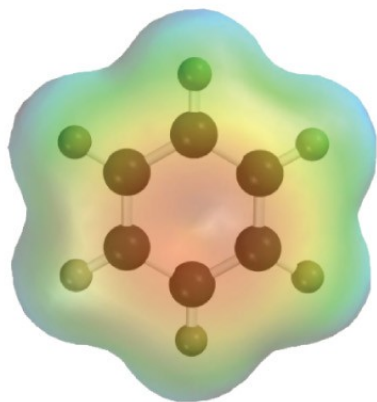
Aspirin



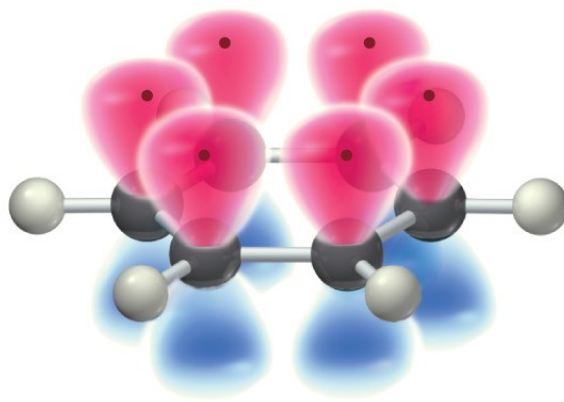
Estradiol

Aromatic Compounds and Their Reactions

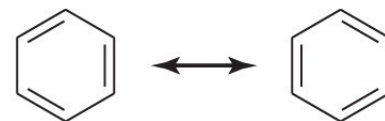
The stability of benzene comes from its six pi-bond electrons which are spread equally around the entire ring:



(a) An electrostatic potential map

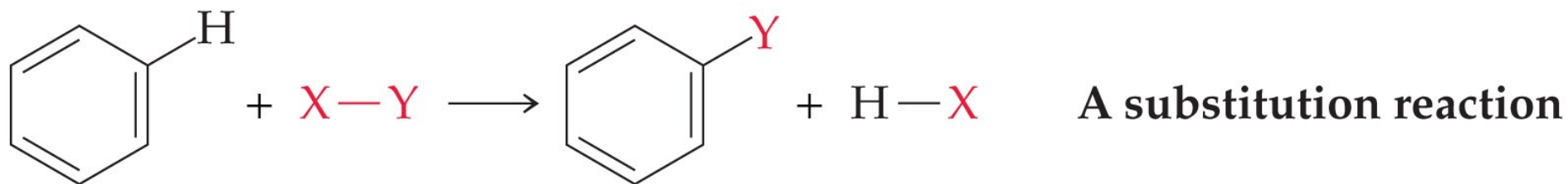


(b) An orbital picture

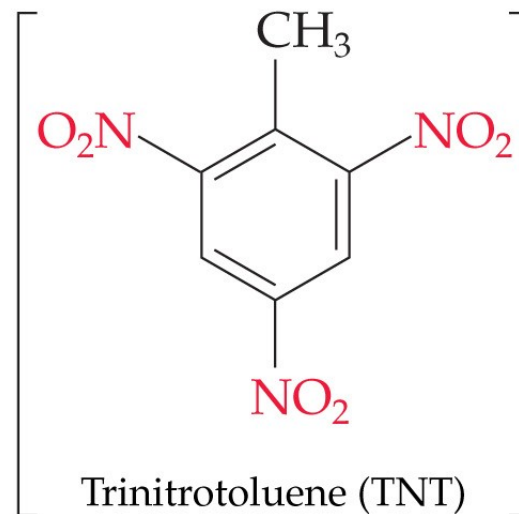
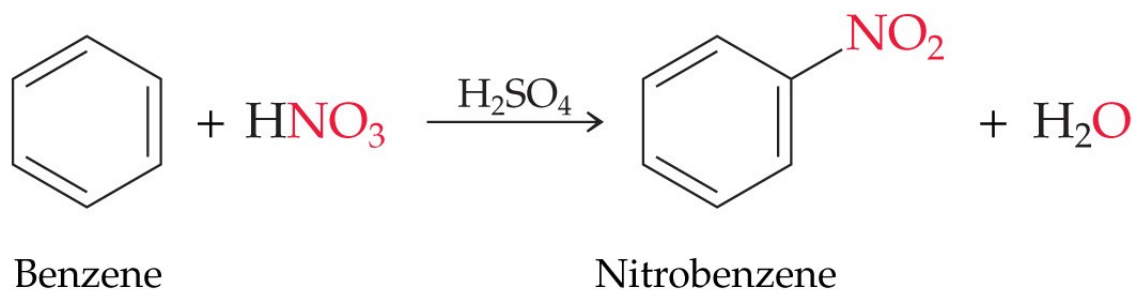


(c) Two equivalent resonance structures, which differ only in the positions of the double bonds

Aromatic Compounds and Their Reactions

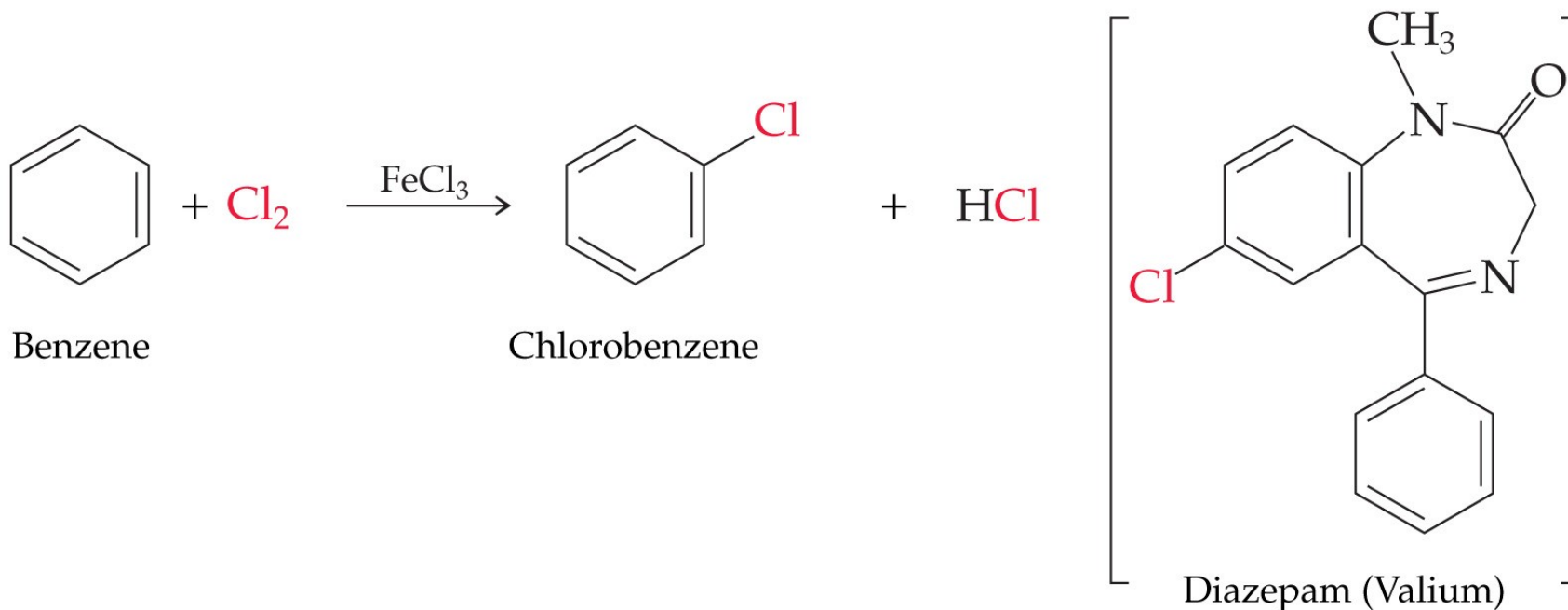


- Nitration (Substitution of a Nitro Group):**



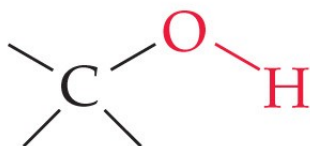
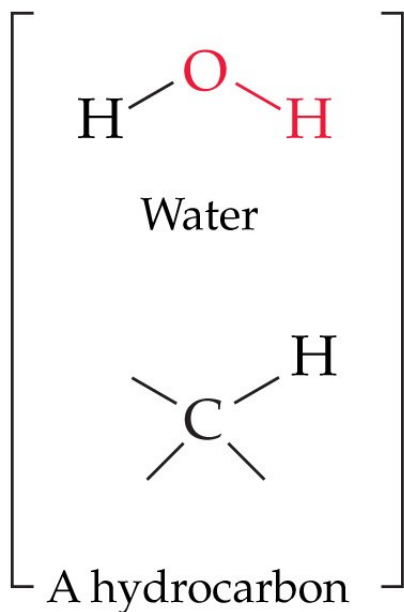
Aromatic Compounds and Their Reactions

- **Halogenation (Substitution of a Bromine or Chlorine):**



Alcohols, Ethers, and Amines

Alcohols: A class of compounds that contain a hydroxyl group (-OH).



An alcohol

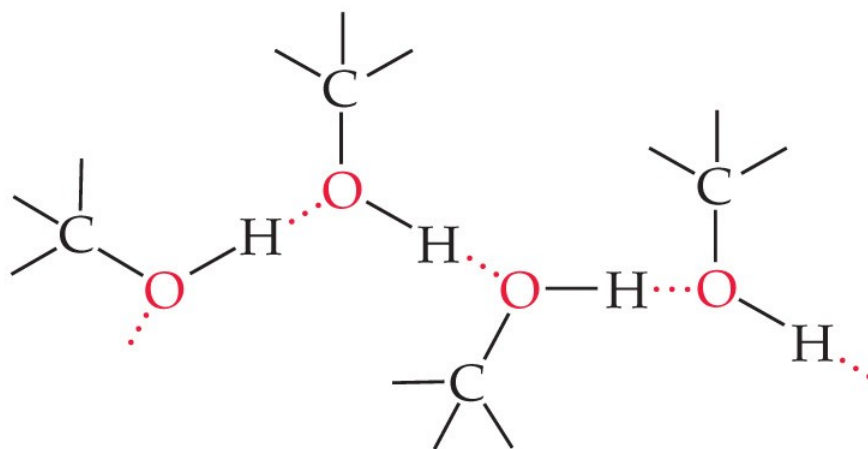
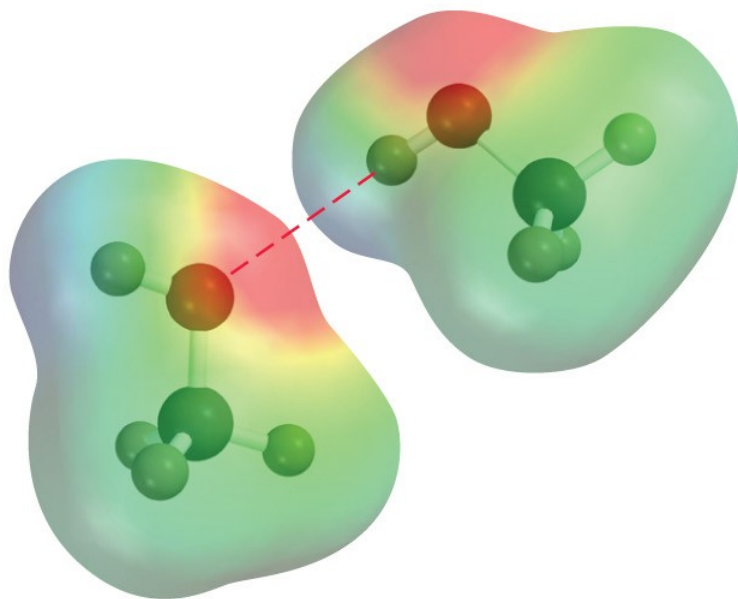
for example: $\text{CH}_3\text{CH}_2\text{OH}$

Ethanol

Alcohols, Ethers, and Amines

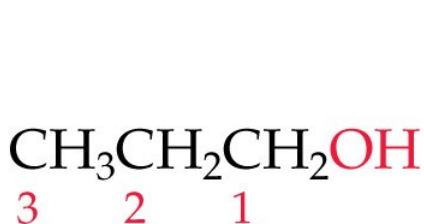
Alcohols

Simple alcohols are often soluble in water because of hydrogen bonding:

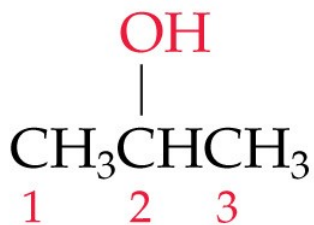


Alcohols, Ethers, and Amines

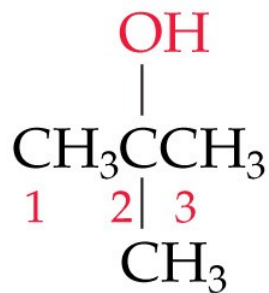
Alcohols



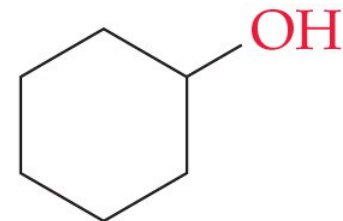
1-Propanol



2-Propanol



2-Methyl-2-propanol

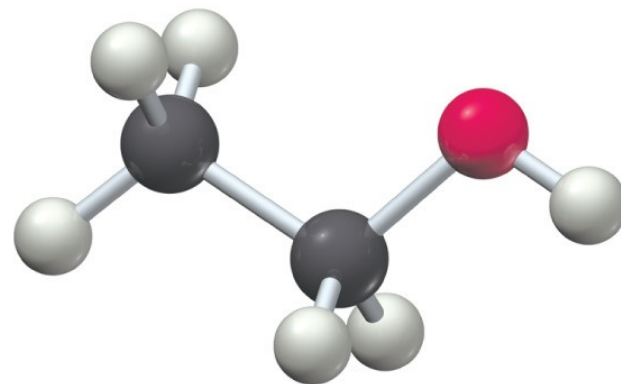
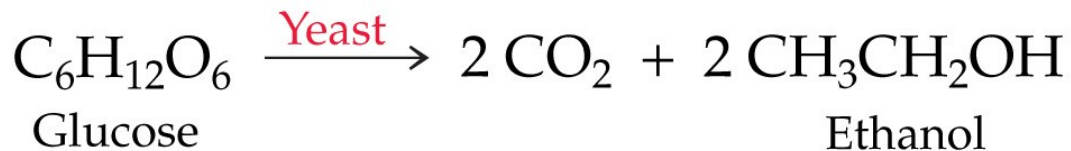
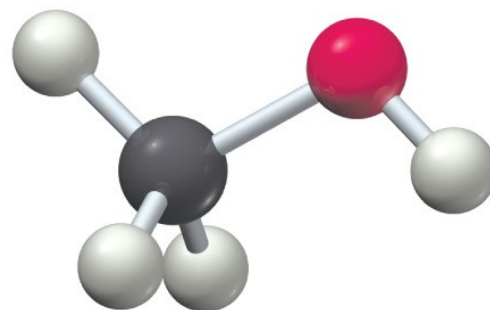
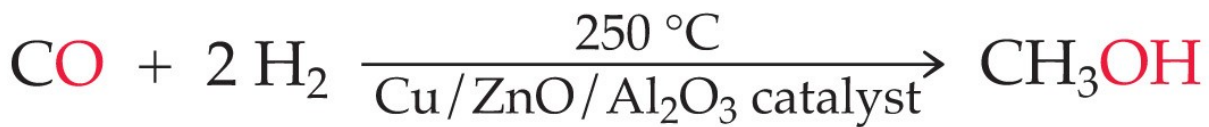


Cyclohexanol

-**ol** suffix since they are alcoh**ols**

Amines

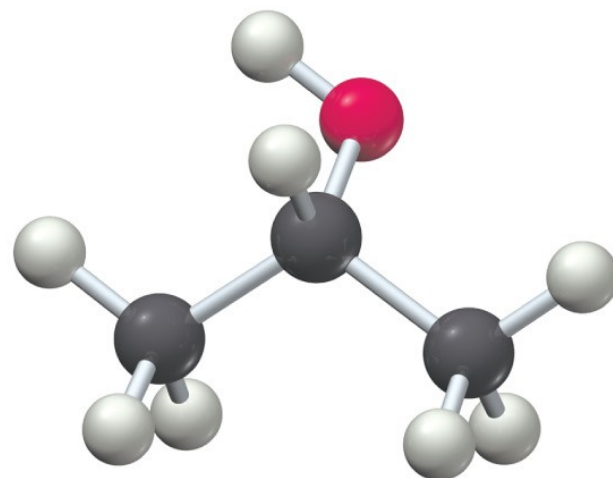
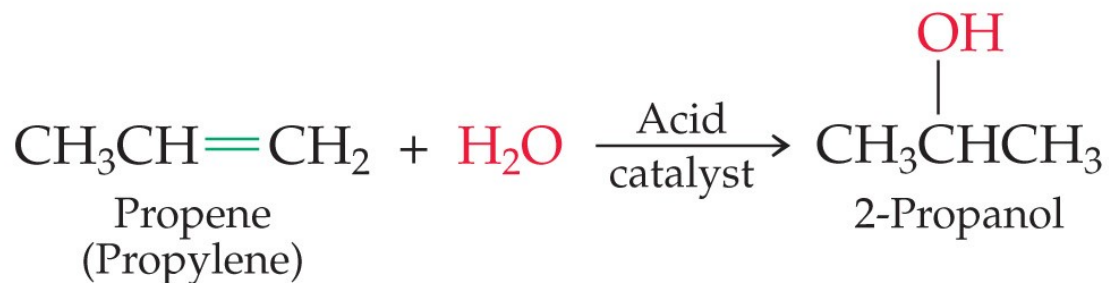
Some important alcohols:



Alcohols, Ethers, and Amines

Alcohols

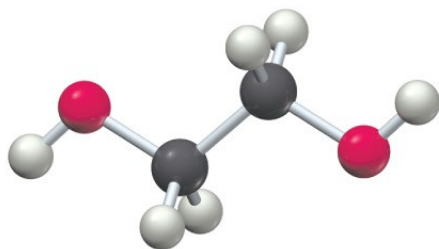
Some important alcohols:



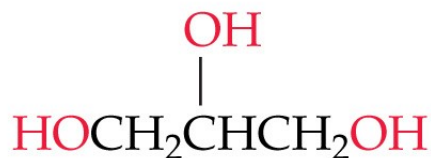
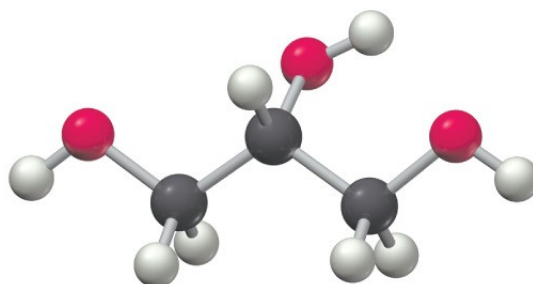
Alcohols, Ethers, and Amines

Alcohols

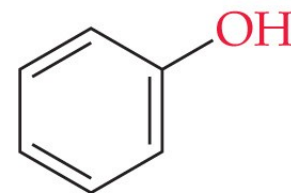
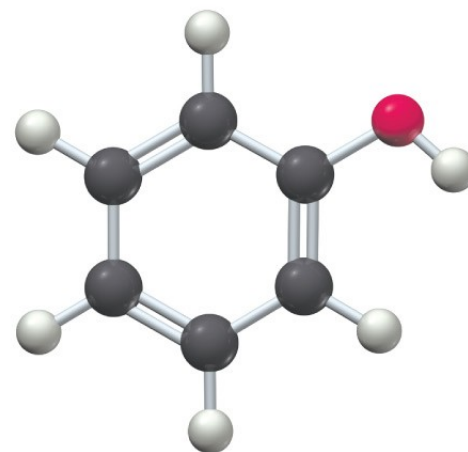
Some important alcohols:



1,2-Ethanediol
(Ethylene glycol)



1,2,3-Propanetriol
(Glycerol)



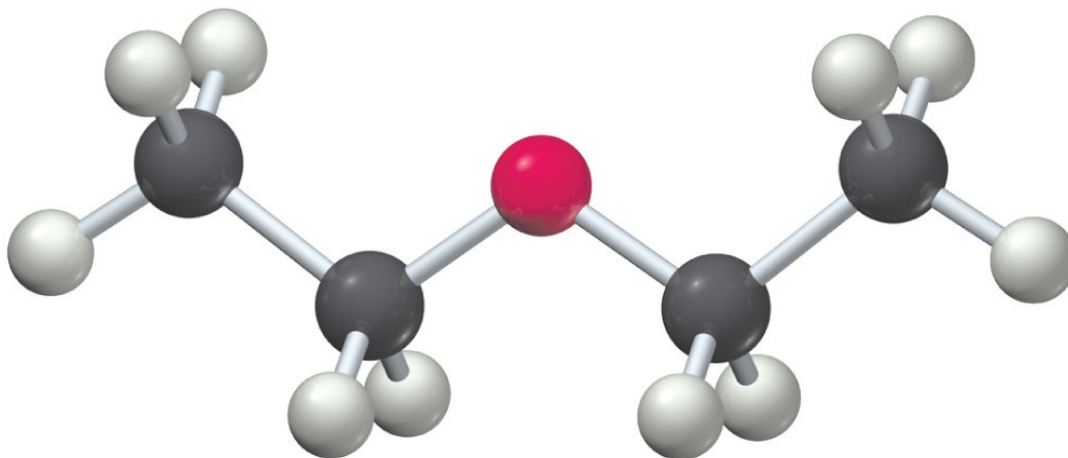
Phenol

Alcohols, Ethers, and Amines

Ethers

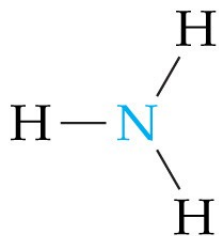


Diethyl ether

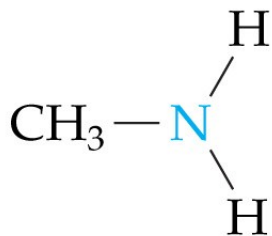


Alcohols, Ethers, and Amines

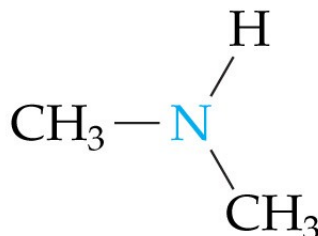
Amines



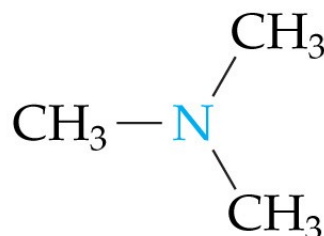
Ammonia



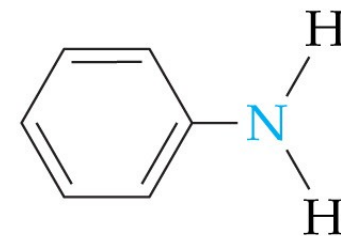
Methylamine



Dimethylamine



Trimethylamine



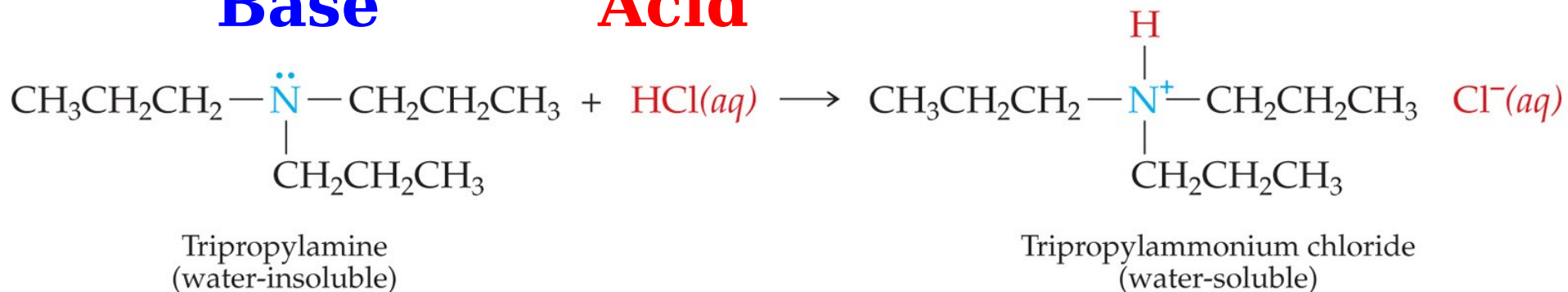
Benzeneamine
(Aniline)

Alcohols, Ethers, and Amines

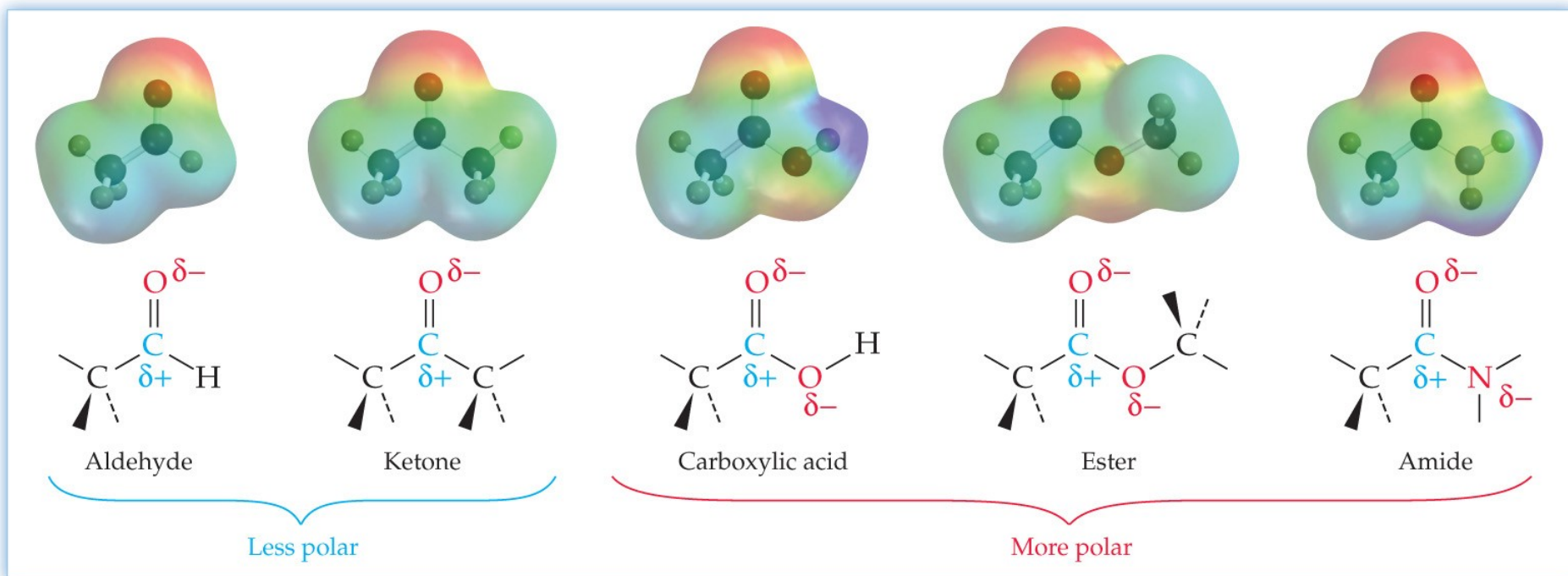
Amines

Base

Acid



Aldehydes and Ketones



All have carbonyl groups

Aldehydes and Ketones



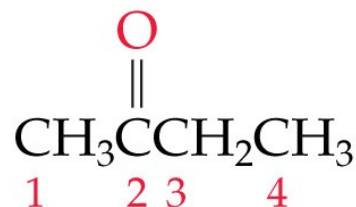
Formaldehyde
(Methanal)



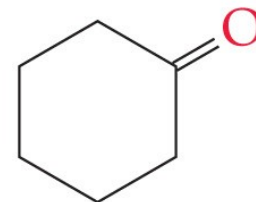
Acetaldehyde
(Ethanal)



Acetone
(Propanone)



2-Butanone

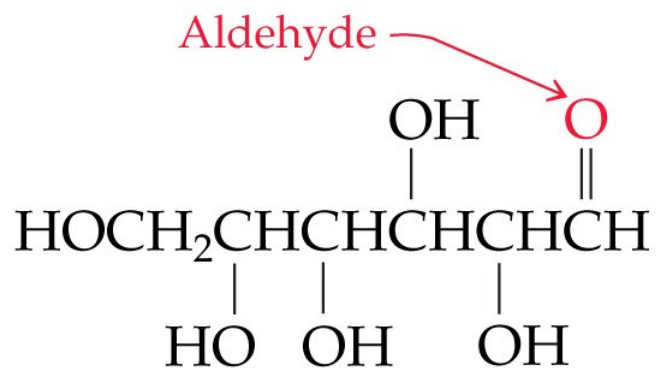


Cyclohexanone

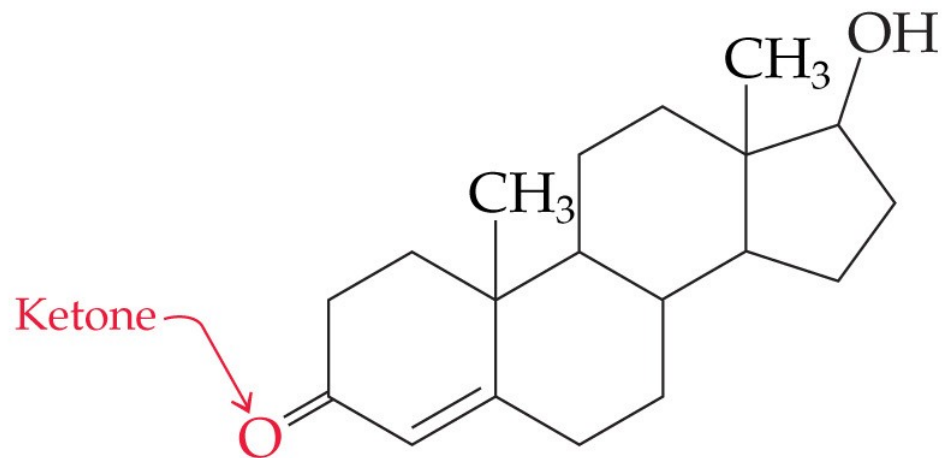
~~-al~~ suffix since
they are
aldehydes

-one suffix since
they are ketones

Aldehydes and Ketones

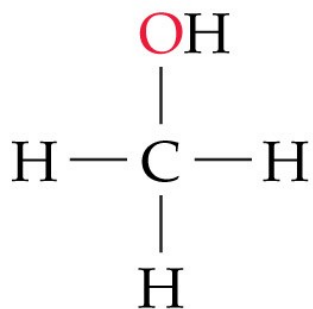


Glucose—a pentahydroxyhexanal

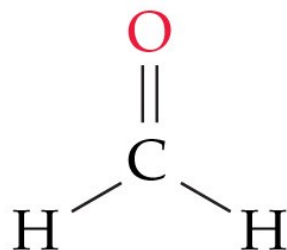


Testosterone—a steroid hormone

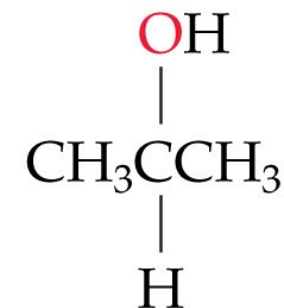
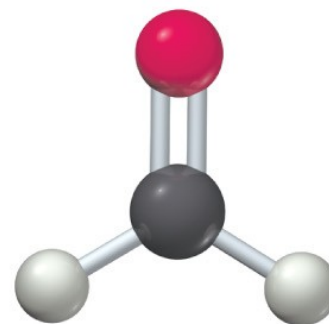
Aldehydes and Ketones



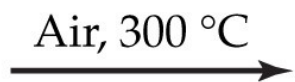
Methanol



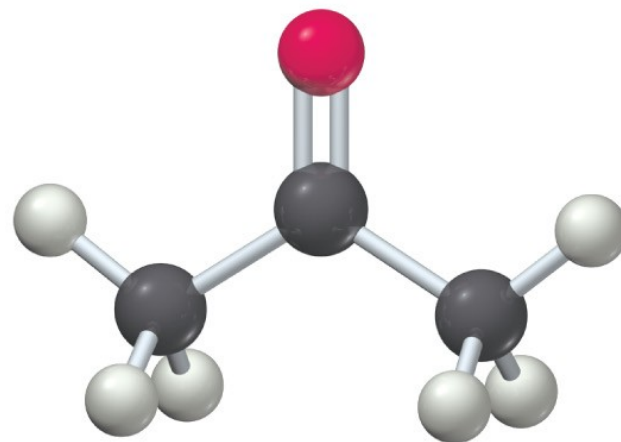
Formaldehyde



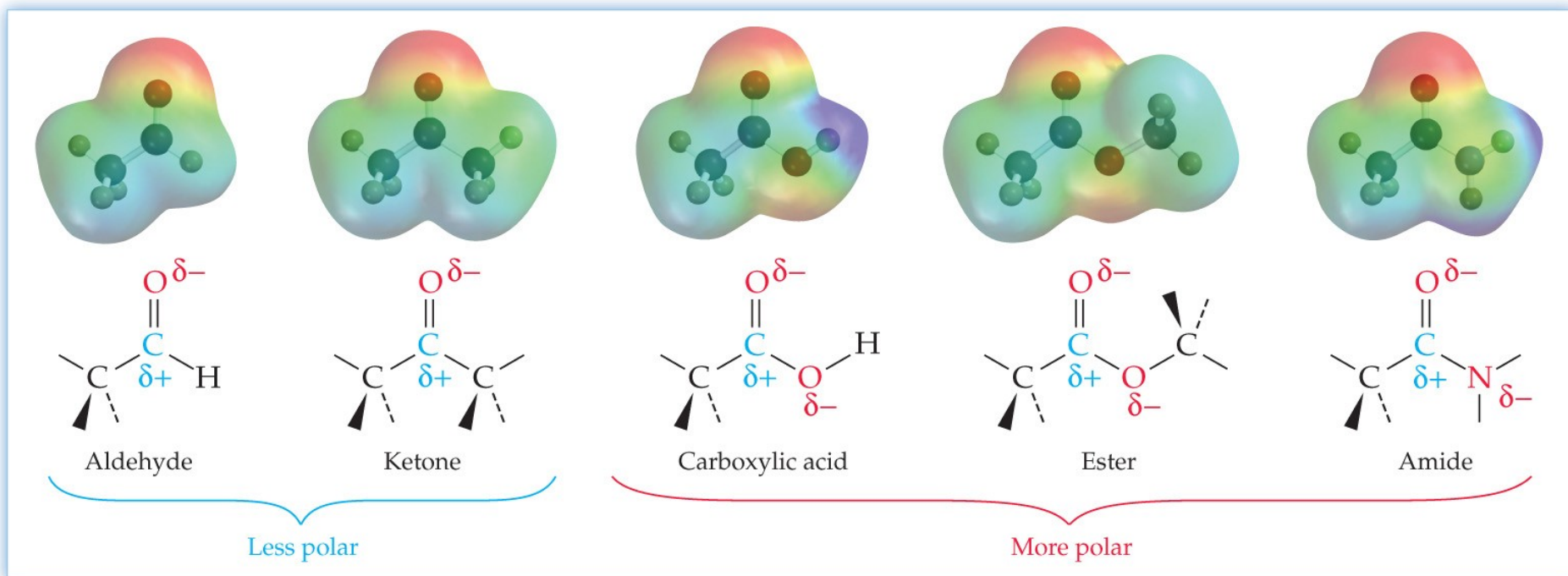
2-Propanol



Acetone



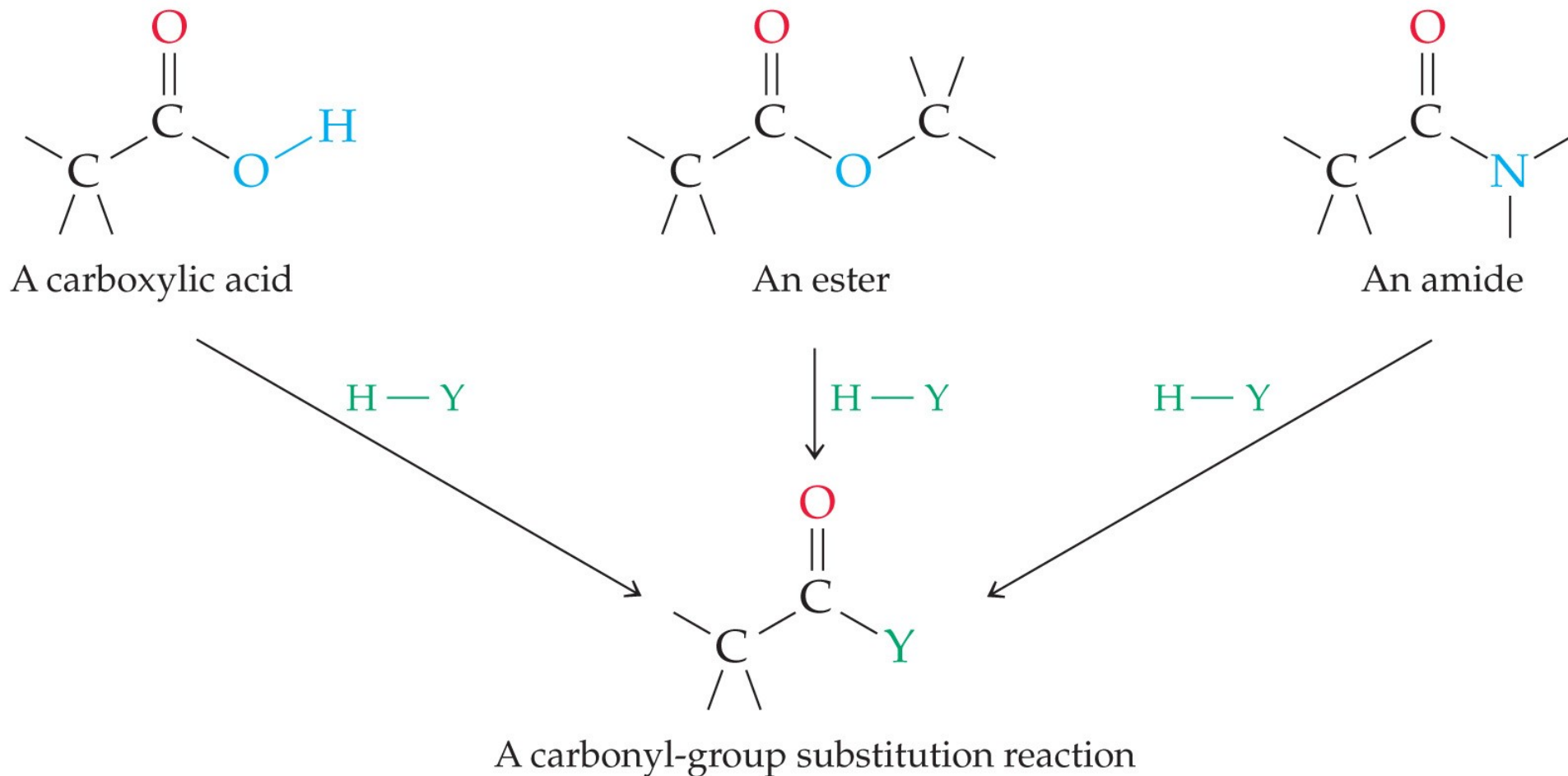
Carboxylic Acids, Esters, and Amides



These are bonded to a strongly electronegative atom (O or N).

Carboxylic Acids, Esters, and Amides

All three undergo carbonyl-substitution reactions:



Carboxylic Acids, Esters, and Amides

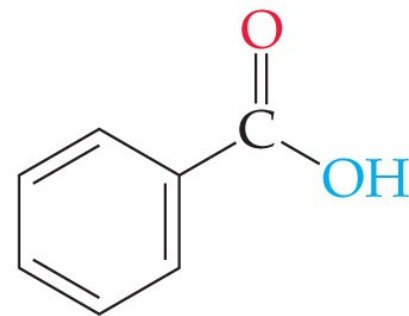
Carboxylic Acids



Acetic acid
(Ethanoic acid)



Butanoic acid



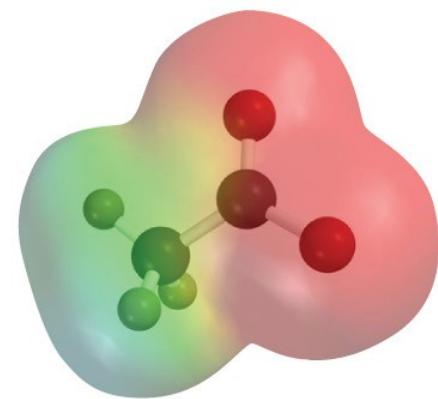
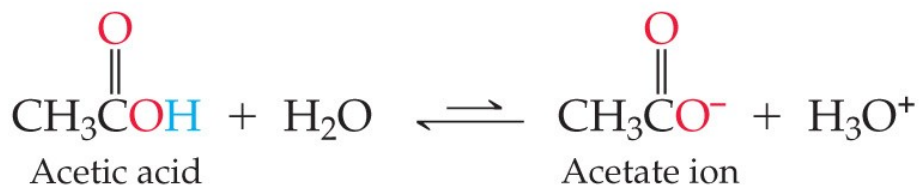
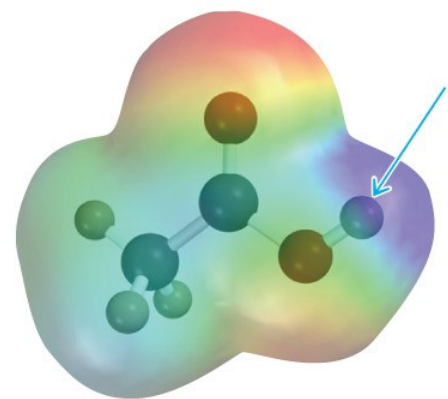
Benzoic acid



Stearic acid
(Octadecanoic acid)

Carboxylic Acids, Esters, and Amides

Carboxylic Acids

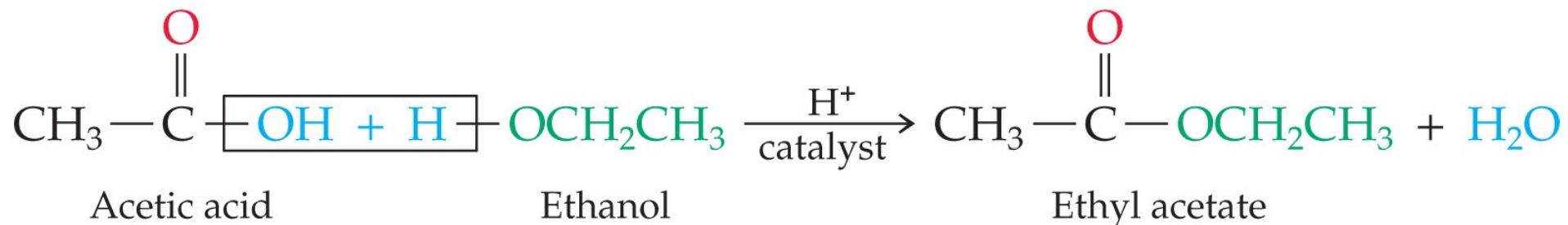


are weaker than their strong inorganic counterparts

acetic acid, $K_a = 1.8 \times 10^{-5}$ ($\text{p}K_a = 4.74$)

Carboxylic Acids, Esters, and Amides

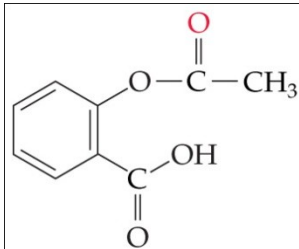
Carboxylic Acids



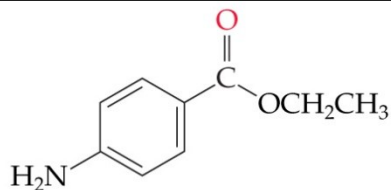
A common
industrial solvent.

Carboxylic Acids, Esters, and Amides

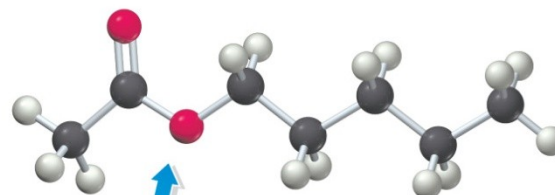
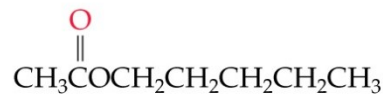
Esters



Aspirin



Benzocaine



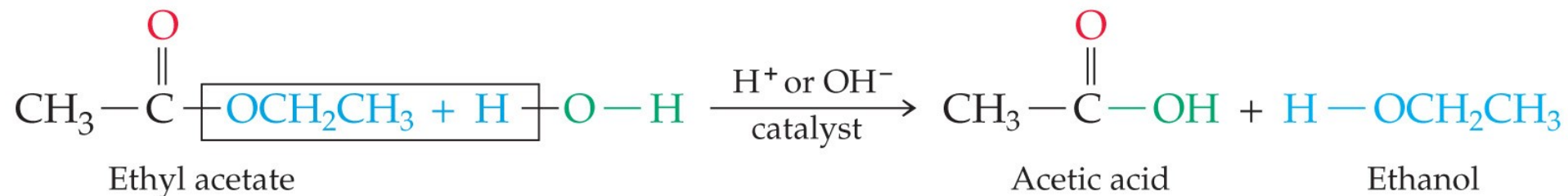
Pentyl acetate



Carboxylic Acids, Esters, and Amides

Esters

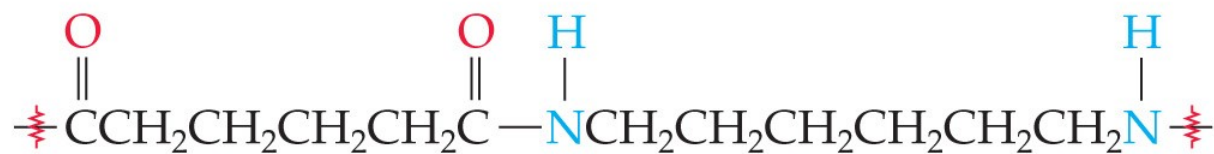
Hydrolysis:



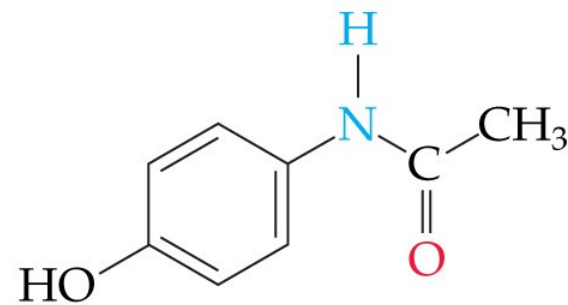
Saponification (“soap”) is the base-catalyzed hydrolysis of naturally occurring esters in animal fat.

Carboxylic Acids, Esters, and Amides

Amides



Repeating unit of nylon 66

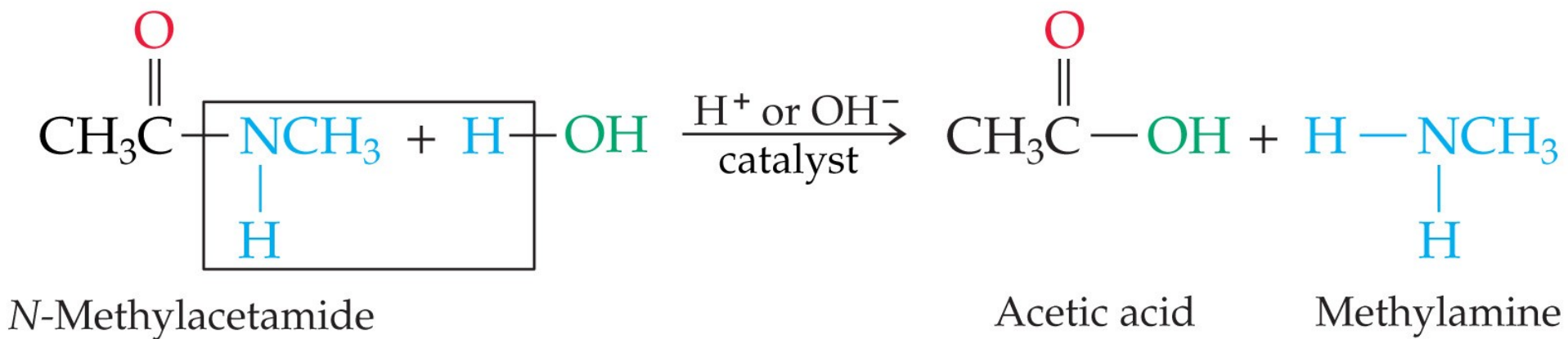


Acetaminophen

Carboxylic Acids, Esters, and Amides

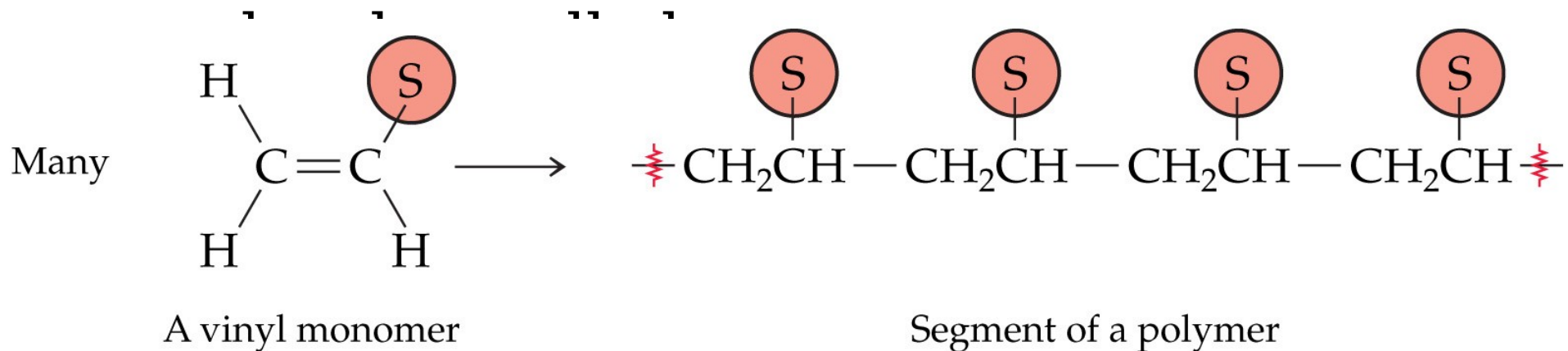
Amides

Hydrolysis:



Synthetic Polymers

Polymers: Large molecules formed by the repetitive bonding of many smaller



where  represents a substituent, such as H, CH₃, Cl, OH, or phenyl

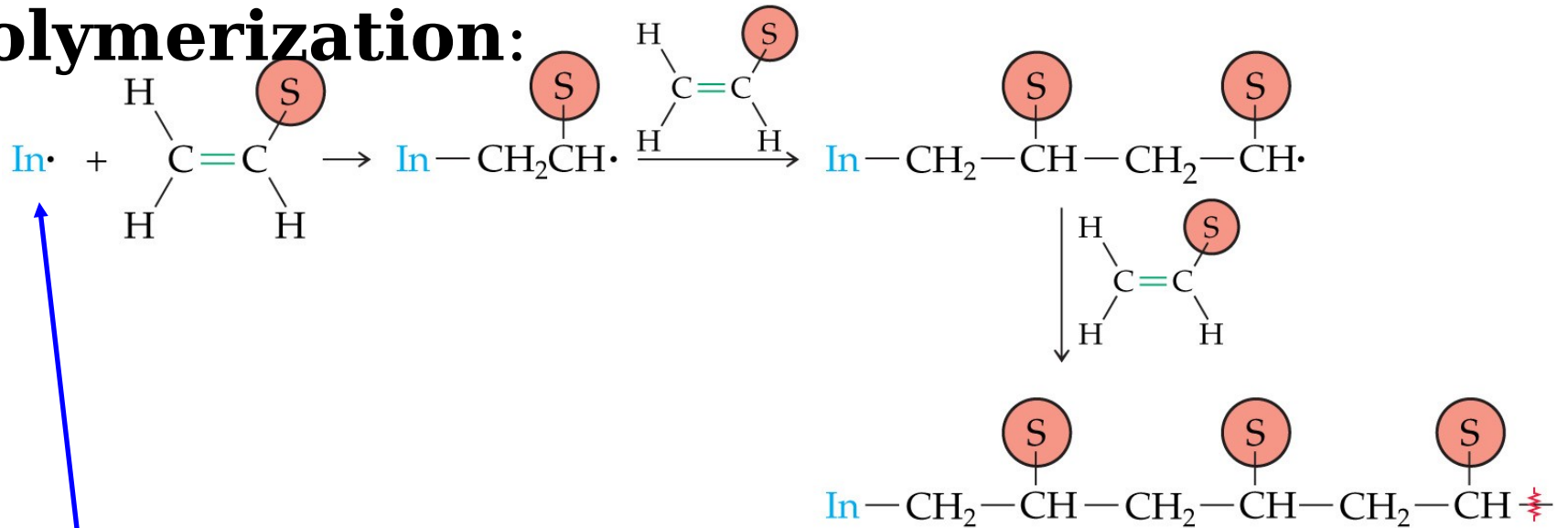
Synthetic Polymers

TABLE 22.3 Some Alkene Polymers and Their Uses

Monomer Name	Structure	Polymer Name	Uses
Ethylene	$\text{H}_2\text{C}=\text{CH}_2$	Polyethylene	Packaging, bottles
Propylene	$\text{H}_2\text{C}=\text{CH}-\text{CH}_3$	Polypropylene	Bottles, rope, pails medical tubing
Vinyl chloride	$\text{H}_2\text{C}=\text{CH}-\text{Cl}$	Poly(vinyl chloride)	Insulation, plastic pipe
Styrene	$\text{H}_2\text{C}=\text{CH}-$ 	Polystyrene	Foams and molded plastics
Acrylonitrile	$\text{H}_2\text{C}=\text{CH}-\text{C}\equiv\text{N}$	Orlon, Acrilan	Fibers, outdoor carpeting

Synthetic Polymers

Polymerization:



Initiator

Synthetic Polymers

Polymerization:

